SCIENCE TODAY AND TOMORROW

Experimenting in Science

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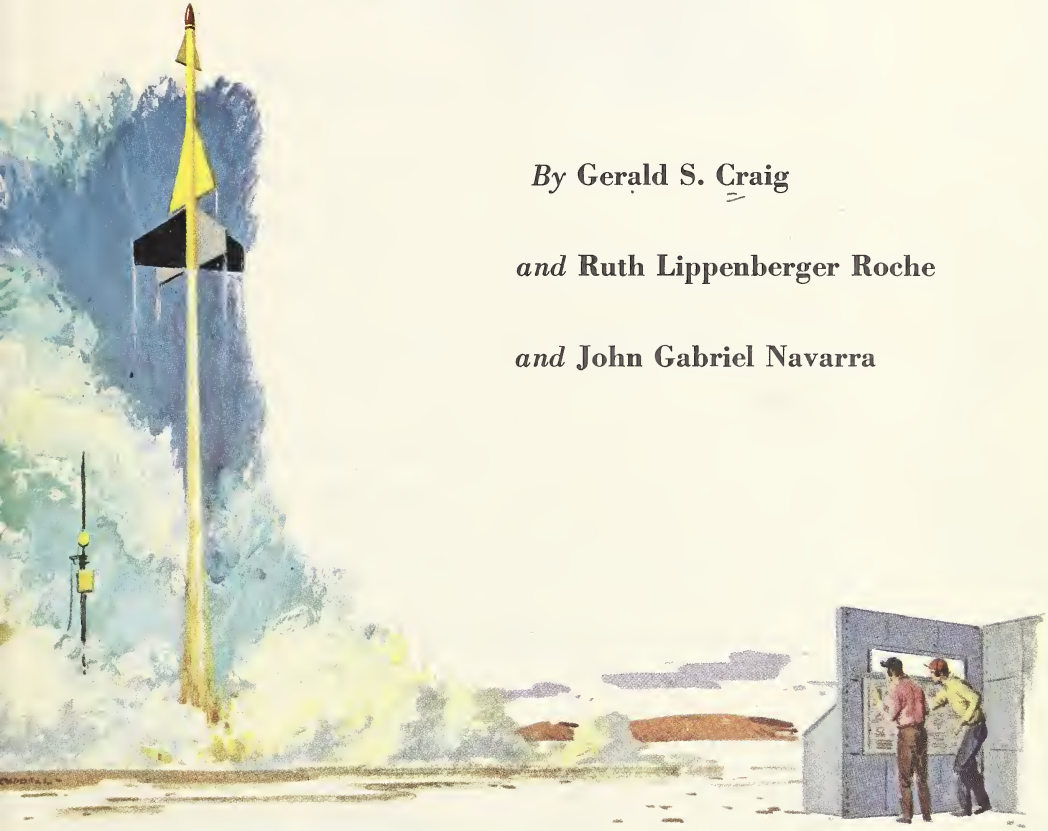
Experimenting in Science



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SCIENCE TODAY AND TOMORROW

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A Teachers' Manual accompanies each book

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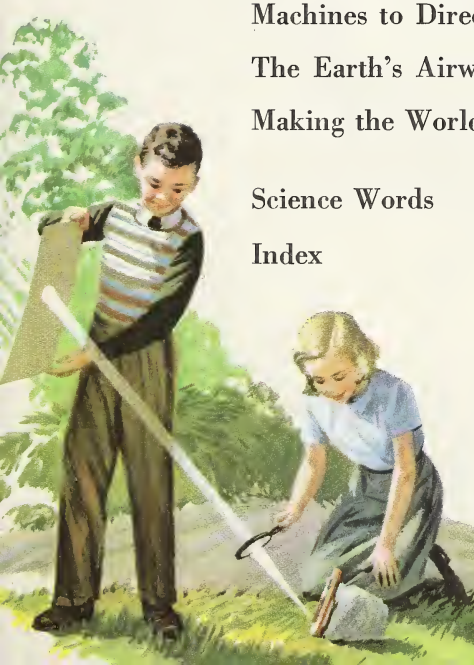

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Energy Everywhere

Where Is Energy?

What a lot of movement there is in the world! Look around you. How many things can you point out that are moving?

You may see a leaf being carried up through the air. We usually think that things fall to the earth because of gravity. What is keeping the leaf from falling? Perhaps clouds are traveling fast across the sky or branches of trees are moving in the breeze. A squirrel may be scampering for cover.

Have you ever wondered what makes all these things move? If you have tried to move heavy things, you know that it takes energy. Whenever anything moves or changes, energy is being used.

No matter where you live, there are signs of energy. When air moves rapidly, you can feel the wind. Perhaps you have seen a section of sidewalk which was lifted up by extreme changes in temperature. You may have seen a bottle that has burst after the water inside it has frozen. Energy is used when a sidewalk lifts or a bottle breaks.

It may surprise you to learn that when an iron pipe rusts, there is energy in that kind of change, too. Yes, a change of any kind involves energy.

Energy is one of the most important things in our lives. Think what the world would be like without energy. It would be a lifeless, cold world in which there would be no light. It would be completely dark. On such a dead world there would be no sound. Nothing would move. There would be no wind, no clouds, no rain, and no snow. In fact, there would be no weather at all if there were no energy.

How Do We Use Energy?

There are many signs of energy. We have talked about some of these signs. Energy sets things in motion. It is used when things change. In how many ways are you using energy at this moment?

Kinds of Energy

Even before you wake up in the morning, you use the energy of your muscles. All the time that you are asleep you never stop moving. Your heart muscle is always moving. Muscle energy keeps your heart beating and the blood traveling through your veins and arteries.

The energy in your muscles keeps your lungs in motion, too. If your lungs were not always in motion, you would not be able to breathe. You use the energy of your muscles to get up, to move around, to work, and to play. You use muscle energy every minute of the day and night. Another name for the energy of your muscles is chemical energy. Chem-

ical energy is stored in food. When you eat food, its energy becomes part of the muscles of your body.

If you have helped your mother with her cooking, you may already be familiar with chemical energy. Have you ever put a spoonful of pancake batter on a hot griddle and watched what happens? The heat of the pan brings about chemical changes in the batter. The energy of the chemicals in the mixture causes it to change in size and shape as well.

You can try an experiment with chemical energy by combining baking soda and lemon juice. Squeeze the juice of a lemon into a glass. Then add a half a cup of water and a teaspoonful of baking soda. When baking soda and lemon juice are mixed together, carbon dioxide is formed. This gas causes the liquid to foam up in the glass. Remember that whenever anything moves, energy is being used. Do you see the motion of the liquid after baking soda has been added?

Something else happens when soda and lemon juice are combined. If you listen carefully, you will probably hear a slight fizzing sound in the glass. Some of the chemical energy has been changed to sound energy. Yes, sound is energy, too.

One of the first kinds of energy you made use of when you got up today may have been sound energy. Perhaps the ding-a-ling of an alarm clock woke you early this morning. The ringing of the alarm was sound energy. You may not think that that was much energy. But it woke you up!

We use sound energy in many ways. Think how many things you

can identify by the sounds they make. Whenever you speak, you are using muscle energy to produce sound energy.

When you rub your hands together on a cold day to keep them warm, you are using muscle energy to produce still another kind of energy. This kind of energy is called heat. A saw becomes warm in much the same way when it is used to cut wood. As a saw rubs against wood, heat is produced.

To produce heat energy, you may use some kind of fuel, such as wood, coal, oil, or gas. If you toasted bread for breakfast, the bread was toasted by heat energy. The red-hot wires of the toaster supplied heat, which browned the bread. Where did the heat come from?

Do you remember connecting the plug on the cord of the toaster to the electrical outlet on the wall? Electrical energy passed through the wires of the toaster and produced heat. A toaster changes electrical energy to heat energy. What else can you name which changes electrical energy to heat?

Other Kinds of Energy

We have talked about energy in chemicals, in your muscles, and in electric wires. Do you think that there is energy in an object such as a ball?

You know that you need energy to throw a ball. But does the ball itself have any energy of its own? Perhaps you have had the misfortune to break a window during a game of baseball. If so, you know

that when a ball is moving, it may have enough energy to shatter a pane of glass. This energy of moving objects is sometimes called mechanical energy. Later you will read how machines have been developed to make use of the energy of moving air and moving water. Mechanical energy is important to us in our daily living.

Perhaps it has never occurred to you that light is a kind of energy, too. If you were not using light energy, you would not be able to read the words that are printed on this page.

Light energy has become so necessary to us that we manufacture light in our homes every night. Each one of our electric lights changes electrical energy to light. It is only through the production and use of light energy that people are able to read, sew, or work after nightfall.

By day most of our light energy comes from the sun. Scientists tell us that the light of the sun is produced when atoms of hydrogen gas combine. This means that the sun's energy is really atomic energy. Directly or indirectly all the kinds of energy we have been talking about probably come from the atomic energy of the sun.

What Is Energy?

Electricity, sound, light, and heat are all forms of energy.

Can you point to something and say that this is electrical energy or heat energy? How would you describe electrical energy or heat energy? You might try to tell someone what it looks like.

Now this seems rather peculiar: we can see what energy does, but no one can hold it up to show the rest of us. Yet there is much energy around us.

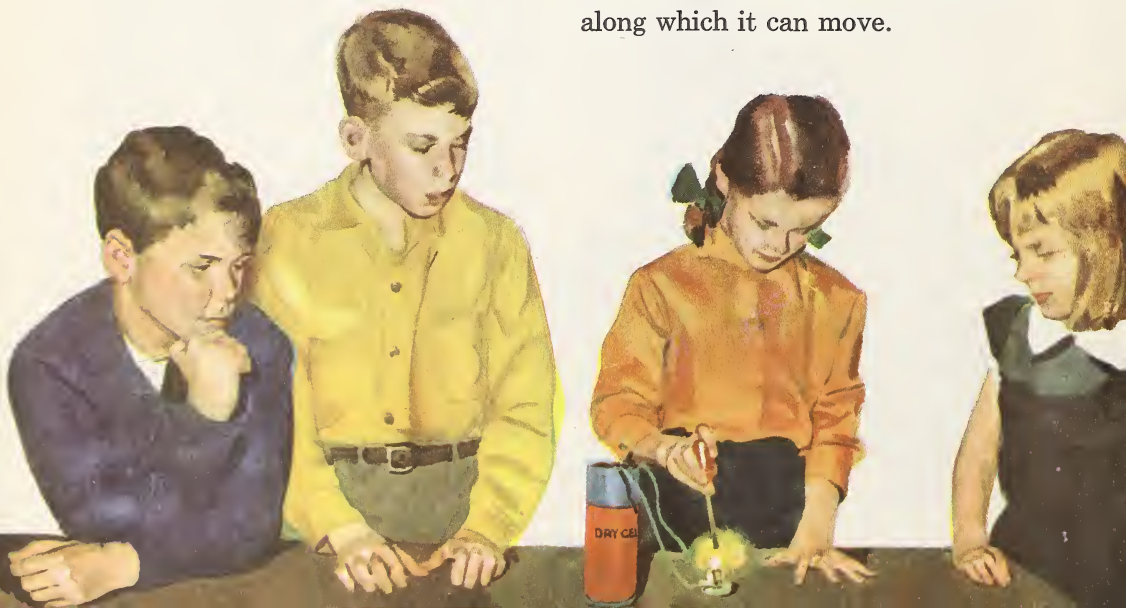
Probably you have held your hand near an electric stove when it was turned on. You could feel the heat. We know that the heat is due to electrical energy. But do we know what electrical energy really is?

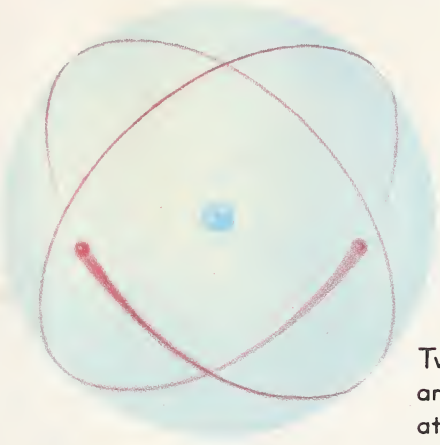
What Is Electrical Energy?

We may hold up a dry cell and say, "Here is electrical energy. We have electricity in this dry cell." When we take a dry cell apart, we will find a zinc can, a carbon rod, chemicals called ammonium chloride and manganese dioxide, and also blotting paper. But can we find any electricity? All we can find will be the zinc, the carbon, and other chemical substances.

Still you insist that there is electricity in a dry cell. You know that if you connect a light bulb and socket to a dry cell by means of wires, the bulb will light. You may say, "Electrical energy lights the bulb." You are right. It is true that we can find no electricity in a dry cell. But when wires are connected to it, electricity flows along the wires.

Here is one reason why you cannot find any electricity when you take a dry cell apart: electricity cannot flow unless there is a pathway along which it can move.





Two electrons spinning around the center of an atom of helium

By properly connecting wires to a dry cell, you form a circuit. This provides a pathway. If you include a light bulb and socket in the circuit, the electrical energy will move from the dry cell along the wire and light the bulb.

After you have taken a dry cell apart, can you still get electrical energy from the chemical substances of which it is made? It would be difficult to do so. You have destroyed the dry cell. In order to get electrical energy, the chemical substances have to be put together and used in a special way.

Atoms and Electrons

Men and women who have studied electrical energy think that electricity occurs because of the way that atoms are built. You may already know that scientists have had a theory for many years that everything is made of small, moving particles called atoms. A very small piece of wood is made of millions and millions of atoms. A piece of glass or anything else you could name is also made of large numbers of atoms.

It seems hard to imagine that all the millions of atoms in a small piece of wood are moving very fast. But scientists think that atoms keep moving all the time and that they contain a great deal of energy.

As each atom moves, the parts of the atom move also. The outer parts of an atom are called electrons. It is believed that electrons move rapidly around the center of each

atom, but some electrons move from one atom to another.

Have you ever scuffed your feet across a rug on a dry day and then touched something? As you touched a doorknob, you may have got a "shock." When you scuff your feet across a rug, you rub electrons off the rug. The electrons collect on your body. Then as you touch a doorknob, the electrons move from your finger tip to the knob. You feel a shock and may see a spark.

We are told that electrical energy is a movement of electrons. The electrons in a dry cell start to move when a circuit, or pathway, is provided. They move from atom to atom in the wires of which the circuit is made. This is not the same kind of movement that you feel when you touch a doorknob, but it is a rather regular movement. People usually call such a movement of electrons a current of electricity.

What Does Energy Come From?

You might like to examine the zinc covering of an old dry cell. If the dry cell has been used a great deal, the zinc covering may be quite thin. There is probably a lot of white powdery material on the inside of it. If you have a new dry cell and an old dry cell, you might compare the zinc covers.

The zinc covering of a dry cell which has been used a great deal is much thinner and lighter than that of a new dry cell. This is because the zinc has been used as a fuel. Energy is released when we use a fuel properly. When zinc is used as a fuel, electrical energy is released.

It may be a little difficult for you to think of zinc as a fuel. When you think of fuel, perhaps you think only of wood, coal, oil, or gas. However, zinc is also a type of fuel, from which energy can be released.

If zinc is to be used as a fuel, it has to be put together with other chemical substances in a special way. It also has to be used in a special way. The zinc is used as a fuel by making it a part of a dry cell and then placing it in an electric circuit.

You cannot release energy unless you use fuel in a special way. Each fuel has its own particular way to be used. Take a piece of coal and crack it with a hammer. Is there any energy released from the coal? No. You can break large pieces of coal into small bits of coal dust. The only thing you will have is coal dust. You use energy to smash the coal, but you do not release any energy from the coal in this way.

You are already familiar with the way in which coal must be used to release its energy. Of course you must burn the coal. When you burn coal, heat energy is released.

What do you have left when you have used the coal as fuel? The

only thing left that you can see is the ash of the coal. While the coal is burning, heat energy is being released. The coal is destroyed when it has been completely burned. It cannot be used as fuel again. In place of the coal destroyed there are heat energy and ash.

Energy from the Sun

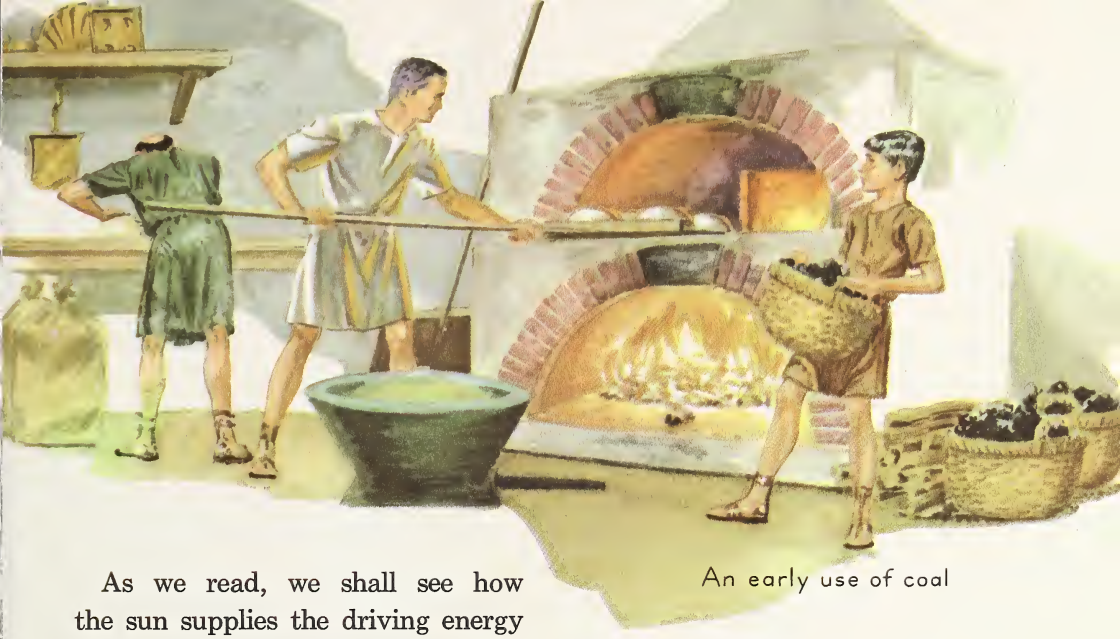
The sun has probably been shining on the earth from the very beginning of the earth. It has kept shining through many, many centuries.

For a long time man has recognized the importance of the sun in his life. Many early men worshiped the sun. The night, to these early people, was a time of great danger. They waited anxiously for the light of day.

Long before man knew much about the sun, he was able to use its energy. He used the energy from the sun to dry his food and to dry hides from which to make clothes. He used the sun's energy to keep himself warm. It is only within the last few years, however, that man has discovered how the sun's energy is produced.

Scientists who have studied the sun tell us that its energy is produced from atoms. We are still learning about the atomic energy of the sun.

Drying food in the sun



An early use of coal

As we read, we shall see how the sun supplies the driving energy which produces winds, rain, and the weather in general. The changes in seasons are really changes in the amounts of energy which reach each region of the earth from the sun.

Man has known for a long time how important energy is to him. He has searched for ways of producing energy. This search has been mainly one of seeking fuels and better ways of using them.

Energy from Coal

Ancient people knew about the material called coal. However, it was a long, long time before someone discovered that this black "rock" would burn.

Can you imagine how the discovery that coal could be used as a fuel was made? Perhaps a piece of coal happened to be left near a wood fire. Just by accident it may have started to burn. Maybe the discovery was made in some other way.

The first written description of coal as a fuel was made over two thousand years ago. A Greek writer described coal as a black rock that would burn like wood.

The early Romans used some coal. However, wood was the fuel used by most people for thousands of years. It was less trouble to gather wood than to dig coal, and it was easier

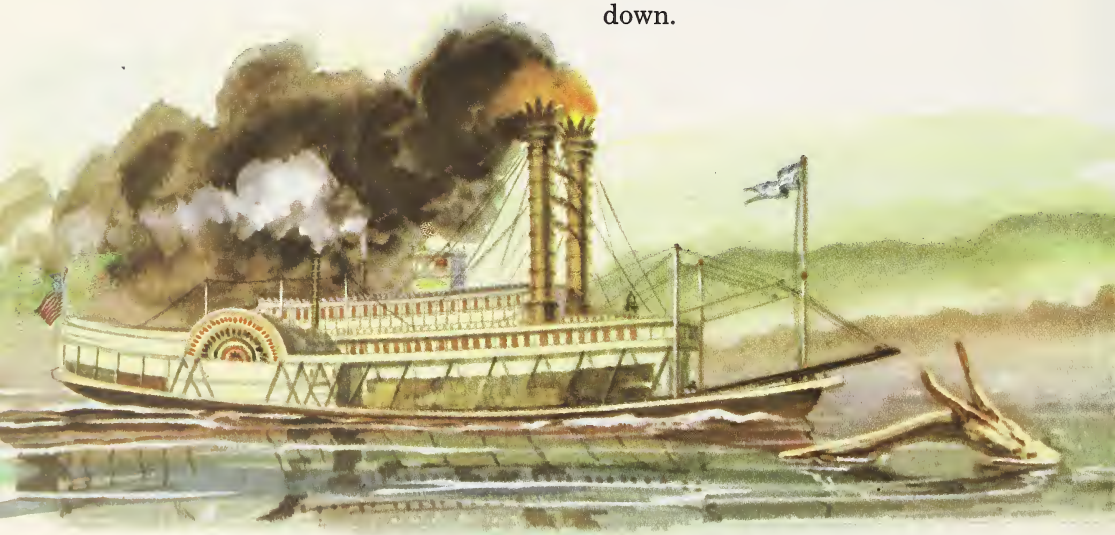
to kindle a wood fire than a coal fire.

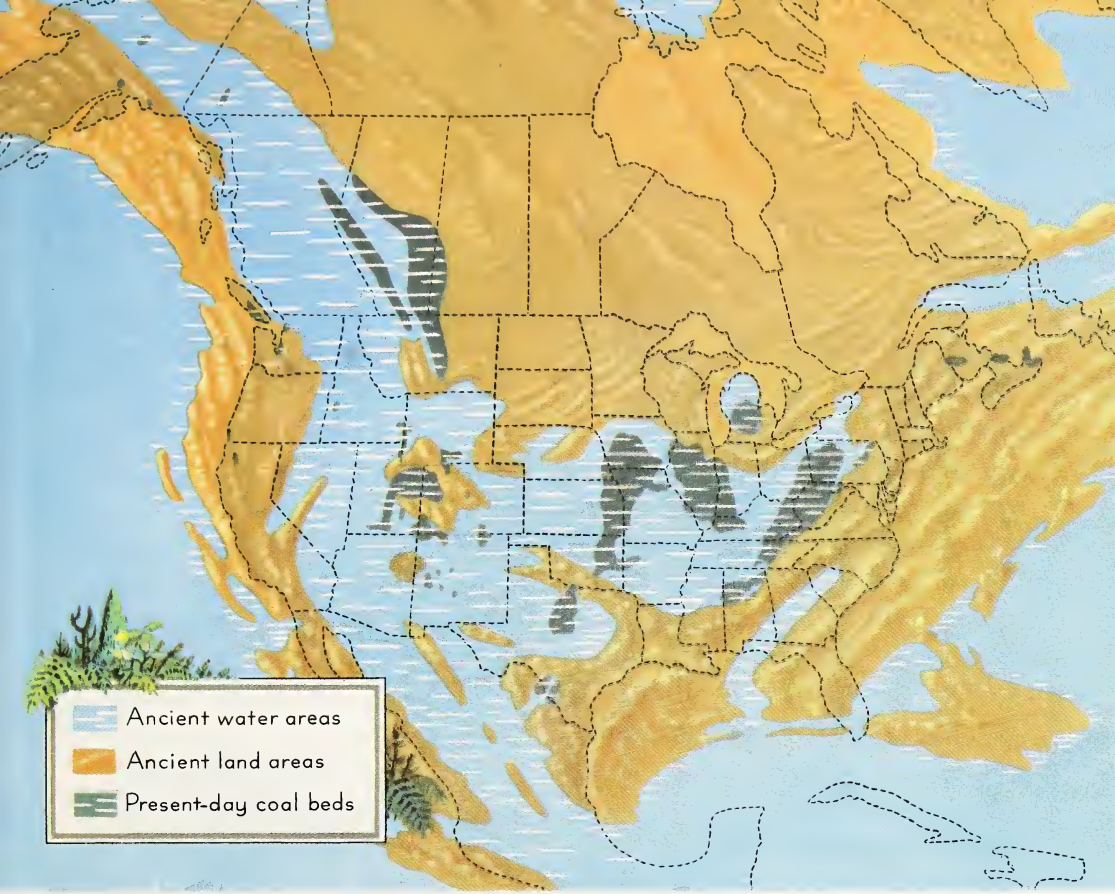
Gradually men began to have need for much hotter fires than they could get by burning wood. For example, blacksmiths needed to heat iron so that it could be shaped and worked. To heat the iron, they needed a hotter fire than they could get from wood. Coal, when used as a fuel, would produce hotter fires than wood. So blacksmiths used coal to produce the heat which they needed to shape the iron.

The invention of the steam engine also showed people the importance of coal as a fuel. When the steam engine was used in boats, wood was first used as fuel. But steamboats need a kind of fuel that will not take up too much space. The fuel must also produce a hot fire. One of the most useful things about coal is that it has a great deal of energy stored in a little space.

"Stored Sunlight" in Coal?

The coal we are using today was formed many millions of years ago. Long ago in the history of the earth large accumulations of plant material occurred. It was then that the greatest coal beds were laid down.





Long before people lived on the earth, great bodies of water called bays covered most of North America. The climate was hot and damp. The air was filled with water vapor, and it was warm the year round, even near the north pole.

At various times the sea level dropped a few feet, and then large swamps developed. Because the air was so warm and damp, the plants in these great swamps grew very fast and very tall. Some of the trees looked like huge ferns, and many of them grew to be several hundred feet high.

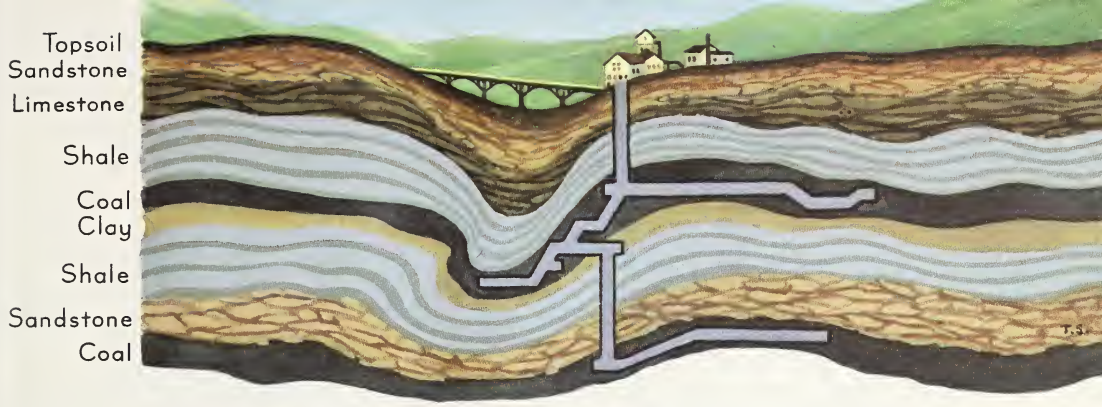
Today we can see a swamp forest very much like those of long ago. It is the great Dismal Swamp between Virginia and North Carolina.

The picture of the Dismal Swamp will give you some idea of how a swamp forest looked many millions of years ago.

As time passed, the trees and other plant life fell into the swamps and slowly began to decay. Instead of decaying completely, they gradually turned into a dark-looking material called peat.

As the sea level rose and fell again, a new swamp would develop in the mud and sand which had covered the old swamp forest. For thousands of years this happened again and again. The plant life in a swamp forest became peat. The peat was covered with water, sand, and mud. Then a new swamp forest grew on top of the peat. Layers formed one on top of the other: first, a layer of partly decayed plant life; on top of it a layer of sand, clay, and mud; then another layer of plant life; and so on.

Gradually the layers of decayed plant life were pressed harder and harder. After a long period of time the pressure became so great that the layers of plant material were changed. Soft, or bituminous, coal was formed. At the same time the layers of sand, clay, and mud were pressed so hard that they turned into rocks called sandstone and shale.



Over many centuries parts of the earth's crust would slowly buckle up or fold over, forming mountains. Whenever layers of soft coal were folded in this way, they received a great deal more pressure. This tremendous pressure changed the soft coal into hard coal, or anthracite.

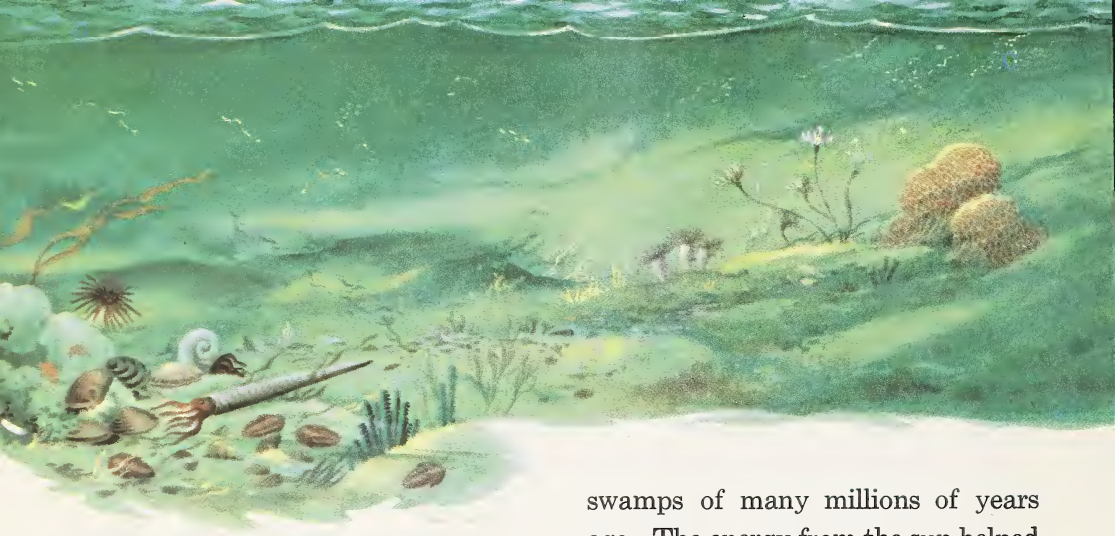
The plants which formed coal grew in the swamp forests of long ago. They needed sunlight to grow. Without the energy of the sun there would have been no coal. For this reason people sometimes say that there is "stored sunlight" in coal.

Plants of long ago made use of the sun's energy in much the same way that plants do today. Some of the energy of the sun actually becomes part of plants because plants are able to make use of light. They use light energy to produce another kind of energy. This energy of plants is called chemical energy. It is the chemical energy of plants which helps to give you health and strength when you eat the plants for food.

How important the energy of the sun shining thousands of years ago still is to us! The light energy was changed into chemical energy by those ancient plants that lived in the swamp forests. The chemical energy of the plants became a part of coal. Man has learned that he can change this chemical energy to heat energy by burning coal.

Energy from Petroleum

In another way man has benefited from the energy of the sun which reached the earth millions of years ago. He has learned to use petroleum as a fuel. We have read how the energy from the sun is used by



plants. Two of the materials which are made by plants with the use of sunlight are fats and oils. We think that petroleum comes partly from plant oils which have been buried for millions of years. We also think that petroleum comes from the bodies of tiny sea animals which lived many millions of years ago. But even the oil from the small animals depends on the energy from the sun, since animals depend on plants for their food.

Petroleum was probably formed by the remains of small animals and plants that were much like those we find in some shale and limestone today. Many of these small animals and plants lived in the seas and swamps of many millions of years ago. The energy from the sun helped the plants and animals to grow.

Billions and billions of these tiny plants and animals died and sank to the bottom of the seas, where they were covered with mud and sand. As time passed, the mud and sand gradually changed to rock. This rock was either shale or limestone or sandstone. Perhaps you can find pieces of such rocks where you live. The different kinds of plants and animals contained oil. But no one knows just how this oil formed petroleum, or crude oil.

Over the years some of the layers of the earth were gradually folded and twisted by great heat and pressure. This folding probably took millions of years. Sometimes the oil from the dead plants and animals

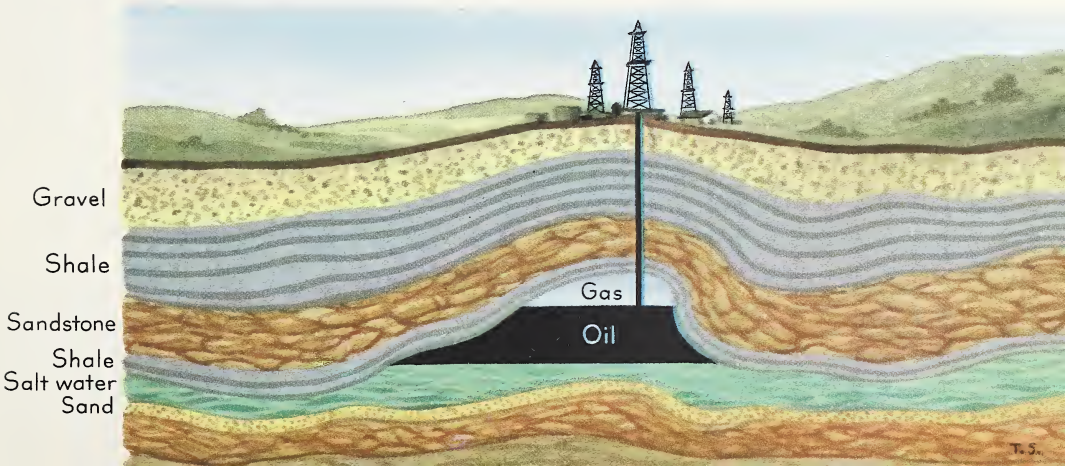
stayed in shale and made it dark and greasy. This kind of shale is called oil shale. In other cases water seeped down and mixed with the oil far below the surface of the earth. The oil floated on the water because oil is lighter than water. As the oil floated, it kept moving up. Some of the petroleum seeped up through beds of limestone or sandstone, much as water fills the pores, or tiny spaces, of a sponge. Finally, it came to a layer or a fold of rock that it could not soak through. There it became trapped.

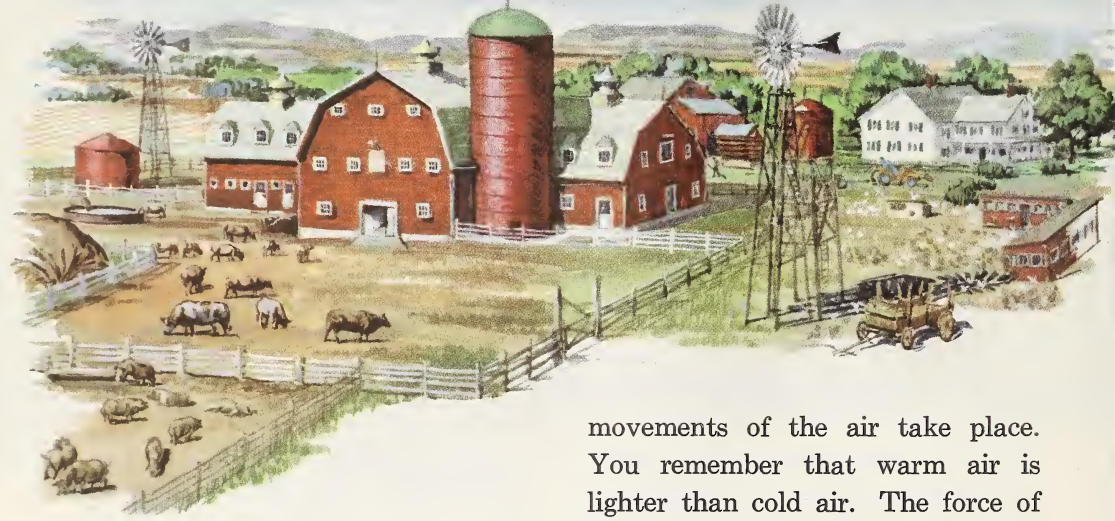
Look at the diagram on this page. Find the fold, or arch, made by the layer of rock. Sometimes petroleum is found under such a fold of rock. Such a place is called an oil trap.

Often there is a layer of shale at the top of the trap. Look at the diagram again. You can see a deposit of natural gas above the petroleum. There is much useful energy in natural gas. Below the oil there is salt water, sand, and a layer of sandstone. Petroleum seeps up through the pores of the sandstone.

Petroleum remains in one of these oil traps in the earth, under great pressure, until a well is drilled. You have probably seen pictures of oil wells that shoot gas and oil into the air. This often happens when a new well is drilled. If you live near oil wells, you may have seen a well "come in."

We have found that we can use the petroleum which comes from a well. We can separate the crude petroleum into various parts by heating it. It can be separated into gasoline, kerosene, diesel oil, and many other products. So you see, a number of other fuels have been made from the natural fuel called petroleum.





The Sun and Wind Power

Wind power is also a very useful source of mechanical energy. It was an even more important source before man learned to get energy from coal, oil, and other fuels. About one hundred years ago wind was the main source of power which drove the fast sailing vessels. These ships were used for transportation and trade. On land man harnessed the wind by means of windmills. He could then use the energy of the wind for many purposes.

Where does the energy of the wind come from? Energy from the sun heats large areas of the earth's surface. Some sections of the air become heated more than others, and movements of the air take place. You remember that warm air is lighter than cold air. The force of gravity will cause the heavier, colder air to move toward the earth. Cooler air may replace, or push out, the warmer air over a section of the earth. This movement of air is called wind. Wind is caused by gravity and the energy of the sun. It takes a lot of energy to make even a small breeze.

The people of The Netherlands have used the energy of the wind to great advantage. They have used it to pump water from the surface of the land. Much of the land that is being used in The Netherlands was once under the sea.

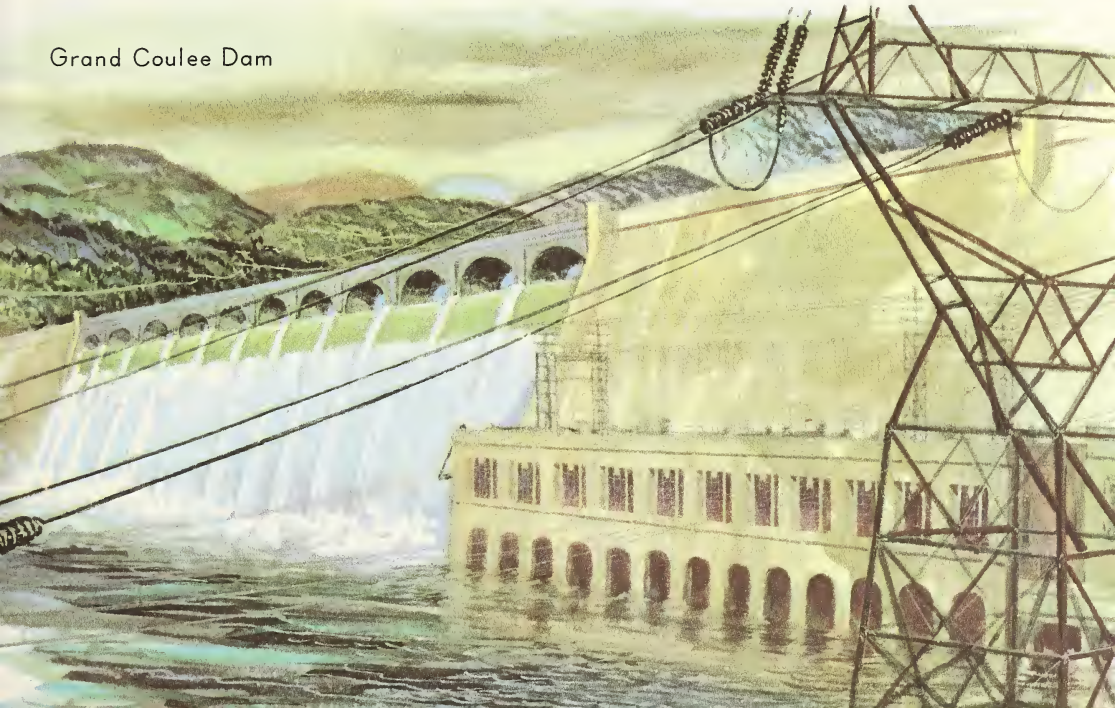
In some western parts of the United States and Canada wind power is used to produce electricity. The wind blows almost continually in these sections. Windmills can be

used to run electric generators on farms in these regions. The people who live on such farms will then have electricity, which they can use for many purposes.

We shall probably learn a great deal more about how to use the energy of wind power. Some experts have thought that wind power will be used much more in the future than it has been in the past. Perhaps you will see this happen in your lifetime. However, the mechanical energy we get from wind power is very unpredictable. We cannot be sure that the wind will produce enough power when we wish to use it.

The Sun and Water Power

Perhaps you have seen water rushing down a mountainside. Have you ever seen running water turn a water wheel? Man has learned how to benefit from the energy of moving water. He has constructed huge dams so that he can use this energy as he needs it. We have many such dams throughout the country. Grand Coulee Dam on the Columbia River is one of these. The energy of the falling water is changed to electrical energy by the machinery at the dam. The electricity is then supplied to homes and factories. Just think of all the electric lights and electric



Grand Coulee Dam

motors that are operated by energy that has come from water power!

You know that all the rivers and other streams finally empty their waters into the oceans. But where does all the water come from? You might say that much of the water once was part of the oceans. The sun provides the energy which takes the water from the oceans and returns it to the land.

When the energy from the sun strikes a body of water, a good portion of the heat energy may reach a depth of about 25 feet. As the energy is absorbed, the water is heated, and some of it evaporates. When liquid water evaporates, it becomes gaseous water. Gaseous water is called water vapor. The water vapor mixes with the other gases of the air near the surface of the water.

You remember that the energy of the sun causes the movements of the air that we call wind. As the air moves from place to place, the evaporated water which is mixed with the gases of the air is carried from place to place also. Perhaps large sections of the atmosphere begin to cool. As the particles of water vapor in the atmosphere begin to cool, they lose heat energy and change back to liquid water.

The change from gaseous water to liquid water is called condensation. When water vapor condenses, the force of gravity causes the liquid water to fall to the surface of the earth as rain. If the rain falls in a

mountainous region, the force of gravity will carry it rushing downhill toward sea level. So you see, a combination of gravity and energy from the sun provides the energy of falling water.

Atomic Energy

We have said that the fuels which supply the energy of the sun are really atoms. So the energy of the sun is really atomic energy. Atomic energy is probably the main source of energy for the universe.

Men who have studied the atom have known for a long time that there are vast quantities of energy inside the atom. They found that these vast amounts of energy could be released. But the problem has been to release the energy so that it could be used when needed to run machinery.

Everyone has heard about the great danger of atomic bombs. However, plans are constantly being developed to use atomic energy for other purposes. It can be used as a source of power for moving ships, for supplying energy to factories, and for many other developments. We are living in a period of very great discoveries. Perhaps you have read in your local newspaper about some of these discoveries.

Remember that man has been using atomic energy from the sun for centuries. The earth has been

Atomic-powered submarine

bathed with atomic energy for millions of years. When you take a sun bath, you are actually being bathed with atomic energy. Man is not able to go up to the sun and control the way in which its fuel is used. But we can do something about atomic fuels here on earth. Atomic fuels present a great challenge. We must learn how to release the energy of the atoms so that it can be used whenever and however we want to use it.

Uranium is one fuel which atomic scientists are using. Uranium is secured from certain rocks and minerals. It is mined from the earth. We have had to learn to use this fuel in a special way in order to produce atomic energy. In fact, we are only just beginning to learn how to use it.

Man Learns to Use Fuel

Man has gradually learned that to release energy, some sort of fuel must be used. To produce heat, man first learned how to burn wood as a fuel. This was a very great discovery which was used in many ways. The energy was used to keep homes warm and to cook food.

Man has learned to use other substances as fuels to produce heat,

light, and mechanical energy. Petroleum has been used only a very short time. Gasoline has to be used in a very special way. Man has invented a special engine to use gasoline as fuel. He uses this engine to run automobiles.

We have also learned much about other kinds of fuels. We have learned to use zinc in a dry cell as a fuel to produce electrical energy. The food which we eat is really fuel that provides muscle energy for our bodies. We are still learning to use fuels to produce energy. Some have been on our earth a long, long time, but we are only starting to use them. Others may be created by man from raw materials here on earth. You probably will use many new and different fuels which are not yet discovered.

LEARNING MORE ABOUT ENERGY

1. Electricity is used in many different ways. How many things can you name for which electricity can be used?

2. Man has learned to use the muscle energy of animals such as the llama, horse, elephant, ox, and dog. Write a story showing how the use of such energy changed the life of early man.

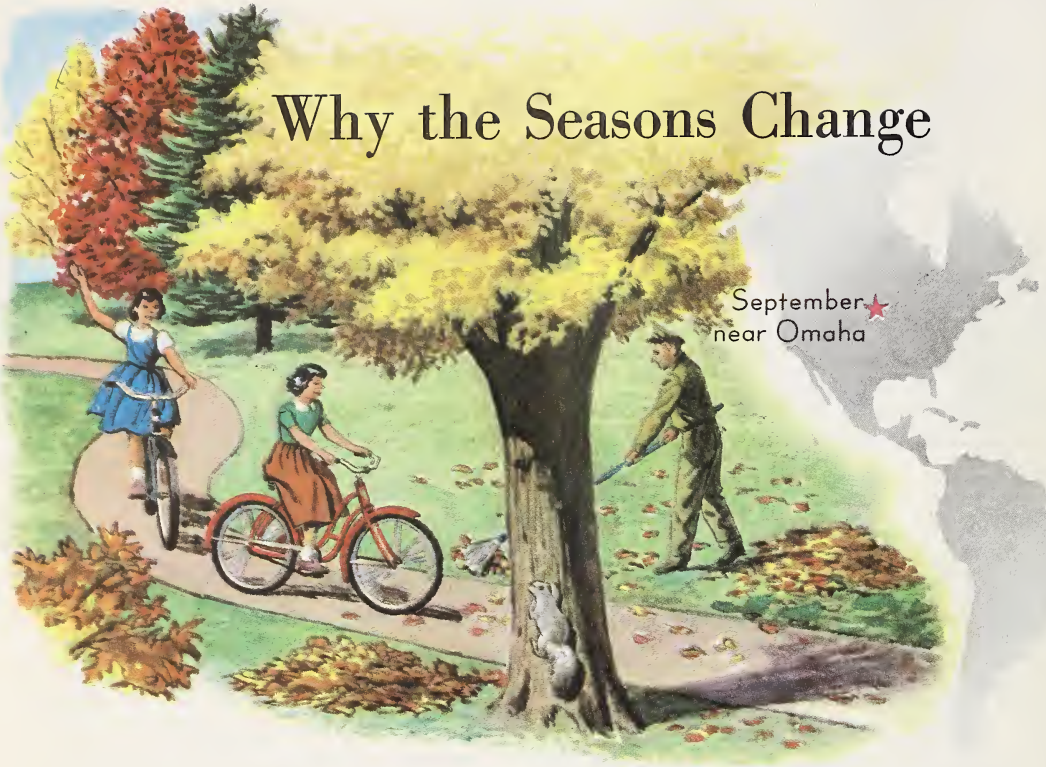
3. There are many different kinds of fuels. Make a list of all the fuels of which you can think. In what way must each fuel be used in order to release energy from it?

4. There may be many manufacturing plants in your community which make energy available for the community. A gas plant, a dam, and an oil refinery are really manufacturing plants which produce energy for the community's use. What are the big sources of energy for the community in which you live?

5. Modern transportation depends on energy which is released from fuels. How have the methods of transportation changed as man has learned to use the energy of fuels?

6. Man is learning to use the energy from the sun in new ways. One of these ways is that of heating homes. There are probably other ways of using the energy from the sun which will be discovered in the future. Your class might like to have a discussion about various new ways of using the sun's energy.

Why the Seasons Change



September All over the World

What is September like where you live? Are the leaves beginning to change color? Is there a crispness in the morning air?

In some parts of North America September is much as it is in the area around Omaha, Nebraska. If you were to visit Omaha during September, these are some of the changes you might see: The leaves are turning from dark greens to golden yellows, deep oranges, and brilliant reds. Many of the brightly colored flowers in the parks are fading. The air is becoming cooler. September is the beginning of autumn in the Northern Hemisphere in parts of North America, Europe, and Asia.

In many parts of the earth September is not as it is in Omaha. Look at a map of the world. Very near the equator, in Brazil, you will find the city of Belém. September in Belém is quite different from September in Omaha. In Belém the leaves are green the year round. September there is much like every other month of the

year. Along the Amazon River, in Brazil, rubber trees and coconut and Brazil-nut trees grow. No one ever needs to wear heavy clothes to keep warm. It is never cold in Belém, and it never snows.

September in some other parts of the world is quite different. In the Southern Hemisphere, in a place such as Buenos Aires, Argentina, September is the beginning of spring. The buds of forsythia are bursting into yellow blossoms. Tiny, bright-green leaves appear on the trees. The days become warmer. People are starting to plant their gardens.

In Omaha September is the beginning of autumn and in Buenos Aires September is the first month of spring. During springtime there is a gradual warming up as the summer season approaches. But during autumn there is a gradual cooling off as the winter season draws near. Develop some of your own ideas to explain why the Southern Hemisphere warms up during the same months of the year that the Northern Hemisphere cools off. Why do you think it is spring in Buenos Aires at the same time that it is autumn in Omaha?

How Sunlight Strikes the Earth

The sun is always shining on the earth. When it isn't shining on the portion of the earth which is having night, it is shining on the side of the earth which is having day. You know, of course, that our sun is a

star. The earth would be a cold, dark, lifeless place without a star nearby to provide both light and heat energy.

Throughout each year, from day to day, the earth receives about the same amount of heat energy from the sun. If this is true, how can some parts of the earth be having their coldest months of the year at the same time that other parts are enjoying their warmest months? Let's see what happens to the sun's energy when it reaches the surface of the earth.

Light Heats the Earth's Surface

Perhaps you have had the experience of sitting in the shade on a warm day. As the earth turned, you found yourself no longer in the shade. The sunlight may have first touched one of your arms or legs, and you could feel its heat. Perhaps you became so warm that you were forced to move back into the shade again.

If there is sunlight coming in your classroom window, you might try this: Stand near the edge of the lighted area and shut your eyes. Hold out one of your arms toward the sunlight. Then with your other hand mark the spot on your hand or arm where you think that the sunlight ends.

Now open your eyes and see how accurately you have been able to judge the area of sunlight. This may help you to see that light energy from the sun changes to heat

energy when it strikes the surface of the earth. You can feel the heat which the light has produced on your arm.

Perhaps you think that you feel heat from sunlight only because the sun itself is so hot. It may seem to you that the sun is like a giant furnace throwing out so much heat that some of it reaches our earth. You may think that the air gets hotter and hotter, the nearer you get to the sun.

Recently when a commercial airliner was flying over Norfolk, Virginia, it was announced that the temperature on the ground was 70° F. But the temperature of the air outside the plane, 20,000 feet high, was only 10° F, or 10 degrees above zero. The people in the plane were 20,000 feet nearer the sun than the people on the ground, but the air was 60 degrees colder.

The explanation that scientists give is that light energy from the sun does not change to heat energy as it passes through the air. But when sunlight strikes the surface of our earth, heat energy is produced. The surface of the earth becomes warm, and this in turn warms the air that is close to it.

December in Omaha

December in Buenos Aires

We know that sunlight does not produce the same amount of heat everywhere. On a December day in Omaha when the sun is shining brightly, the air may be crisp and frosty. There is often enough ice on the ponds for you to go skating. There is not enough heat energy to melt the ice. But on this same day in Buenos Aires the temperature might rise to 80° F. You could go swimming in December in Buenos Aires. Why does sunlight produce different amounts of heat in different parts of the earth?

How Light Heats a Small Space

The size of the space which a beam of sunlight covers affects the amount of heat energy received. You might try an experiment which will help to show you whether this is true. You will need a magnifying glass, an outdoor thermometer, a large piece of cardboard, and a pair of scissors. You will also need sunlight for this experiment. If none shines through your classroom windows on sunny days, perhaps you can go to a room where the sunlight does shine.

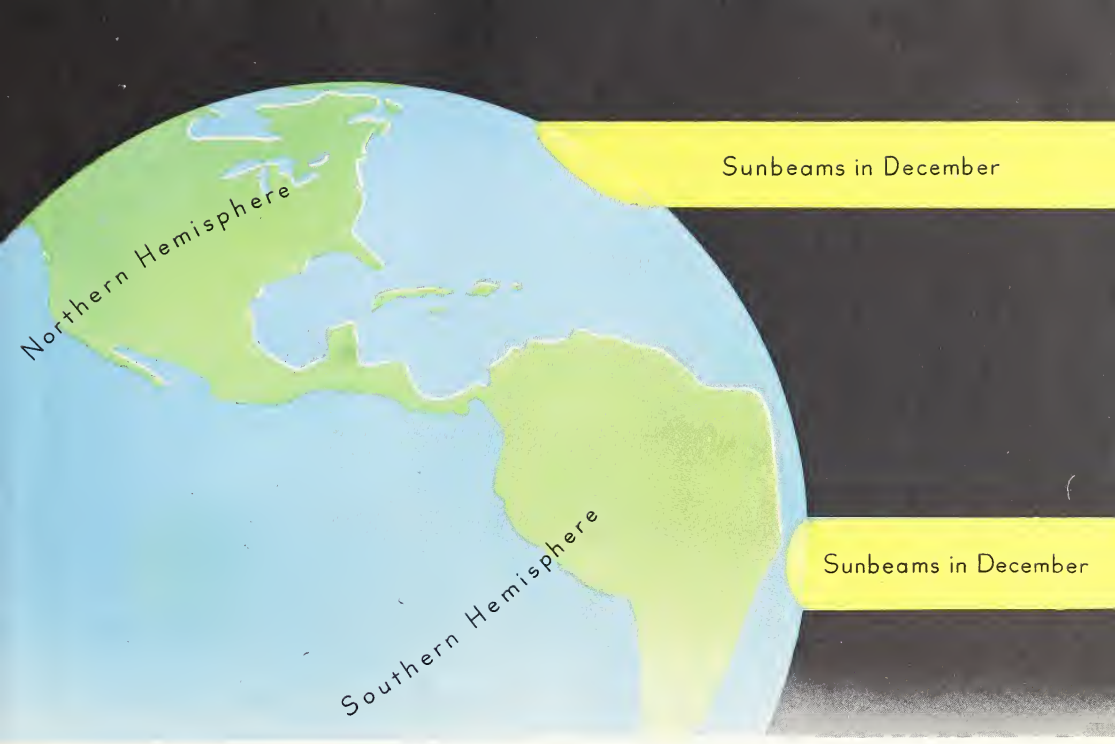
Cut a small hole in the piece of cardboard and place this cardboard in front of a sunny window. Now you will have a beam of sunlight coming through the hole. Hold the cardboard so that the beam of light falls on a table.

Have someone place an outdoor thermometer so that its bulb is in the spot of light on the table. Notice that the liquid in the thermometer rises. Record the temperature for a spot of sunlight of this size.

Now hold a magnifying glass in front of the beam of sunlight coming through the hole in the cardboard. Do you see how much smaller this makes the spot of light on the table? The same amount of light is coming through the hole in the cardboard, but the light covers a smaller space than it did before.

Shine the smaller spot of light on the bulb of the thermometer. Do you see how rapidly the liquid in the thermometer rises? You should remove the magnifying glass very quickly. There is so much heat energy in the small spot of light that it is not safe to keep it shining on anything too long.

You have found that the temperature in the smaller space was a great deal higher than it was in the larger area. This does not mean that the total amount of heat energy from the sunbeam had changed. But it



does mean that when the light energy covers a smaller space than before, there is more heat energy in the smaller space.

The same thing is true of sunlight wherever it falls on the earth. When light covers a small space, the heat increases. When the same amount of light spreads out over a wide area, the heat is spread out also, and there is not as much heat energy at any one spot.

Now do you see one reason why sunlight falling on Omaha in December might produce less heat energy than the same amount of sunlight falling on Buenos Aires? Something must happen to the light at Omaha to cause it to spread out more than it does on the same day in Buenos Aires.

Light Spreads Out on Tilted Surfaces

We have done an experiment which shows us that it is possible to change the size of the space which a beam of light covers without changing the size of the sunbeam. You might try another way of doing this.

Look at the drawings on these two pages to see how you might try the next experiment. You should have a flashlight, a piece of paper rolled into a tube, and two pieces of cardboard. It would also be a good idea to have the room as dark as possible.

First, put the flashlight inside the paper tube. Have a classmate hold one piece of cardboard straight up and down, just as the boy in the drawing below is doing.

Turn on the flashlight and stand so that the open end of the tube is about 1 foot from this piece of cardboard. The flashlight will shine on the cardboard. Have someone draw a line around the lighted spot with a colored crayon.

Now have a classmate hold the second piece of cardboard tilted as the boy in the drawing on the next page is tilting his. Then shine the flashlight on the tilted piece of cardboard in the same way and at the same distance as before. Again draw around the lighted spot. Then cut out the two spots that were outlined with crayon. Place one on top of the other. Are they the same size? Does the spot made by the beam of light on the tilted cardboard cover more space?

In both parts of the experiment the same amount of light energy

strikes the cardboard. But when the light strikes the tilted cardboard, it spreads out and covers more space. Sunlight too spreads out when the surface which it strikes is tilted.

Now we have three clues to tell us why the earth has seasons. We have learned that sunlight is changed to heat energy when it strikes the surface of the earth. We have also found that the amount of surface a sunbeam spreads over affects the temperature. Finally, we have found that the amount of surface that is lighted and heated changes as the surface tilts.

Our Tilted Earth

We have said that it might be cold enough to go skating on a sunny December day in Omaha. Perhaps you could go swimming on this same day if you lived in Buenos Aires.

In December the sunlight produces less heat energy in Omaha than it does in Buenos Aires. The tilt of the earth has something to do with this difference in temperature. To

understand this, we must first understand what is meant when we say that our earth is tilted.

If the Earth Did Not Tilt

First, let's see how sunlight might fall on the earth if the earth were not tilted. You can use a tennis ball to represent the earth. Push a pin part way into the tennis ball. It should be in firmly enough for you to lift the ball by holding the pin. Then insert another pin lightly on the other side of the ball exactly opposite the first. With a pencil or a crayon draw a line on the ball all the way around it, halfway between the two pins. This line represents the earth's equator. After you have drawn the line, you will not need the second pin and you can remove it.

Now you are going to shine a flashlight, representing the sun, on the ball. It would be a good idea to put the ball on a piece of paper on a table and mark the spot where it rests, so that you will be able to put it in this same place again later on.

Hold the ball up by the remaining pin so that the ball is just lightly touching the paper. Have a classmate arrange a flashlight on books on the table at the right height and distance so that the light will shine most brightly on the ball at the line which represents the equator. It will help if the room is darkened.

Now let's imagine that the tennis ball is really the earth and the flashlight is the sun. Notice that the light spreads out about equally above and below the equator. If this were the way that sunlight fell upon the earth, what could you say about the seasons?

The areas north and south of the equator would receive the same amount of energy from the sun the year round. December in Omaha would not be very different from December in Buenos Aires. But we know that this is not the case. Let's see what happens when we experiment with a tilted ball.

Our Earth Is Tilted

Still holding the ball by the pin that was inserted, rest the ball on a table. Again shine the flashlight on the line representing the equator, but this time tilt the ball away from the light. The picture on this page will show you how much to tilt it.

Do you see that there is now less light above the equator than before? The amount of light energy shining on the ball has not changed. But now the light is brighter below the equator than above it. What season would this represent in the Southern Hemisphere? Would it be warm or cool north of the equator? Remember that wherever the light is brighter, there is more heat also.

We know that at times on our earth areas north of the equator may be covered with ice and snow while fields are green in the Southern Hemisphere. At other times the opposite is true. In June the air is cool and wintry in Argentina, and the children wear warm clothes to school. In the Northern Hemisphere summer vacation is beginning in June.

The seasons are different as different parts of the earth change their positions in relation to the sun. This happens because our earth is tilted.

The Earth Moves about the Sun

You know, of course, that the earth is a planet revolving about the sun. You know, too, that the earth is rotating, or spinning, as it moves about the sun. It takes the earth one day, or about 24 hours, to spin around once. To make one complete journey about the sun takes our spinning earth one year, or about $365\frac{1}{4}$ days. Another way to say this is that the earth rotates $365\frac{1}{4}$ times while it revolves about the sun once.

As the earth spins around, day follows night, but the number of hours of daylight are not always the same on all parts of the earth. Can you remember summer evenings when the sun did not set until long after suppertime? Now think of the wintertime. Does the daylight begin

to fade on winter days even before you have had supper?

We think that the number of hours of daylight each day has some effect on temperatures. When the days are long, there are more hours for the surface of the earth to be warmed by the sunlight. There is less time at night for that part of the earth to cool. Winter days are short, and summer days are long. This is true in Omaha and it is true in Buenos Aires. Don't forget, however, that Omaha is having winter at the very same time that it is summer in Buenos Aires. This means that the same day can be long in one place while it is short in another.

Something You Can Do

This is something you can do which will help you to understand how the earth moves around the sun: You will need an electric light, some clay, cardboard, and toothpicks. You will also need a globe somewhat like the one in the picture above.

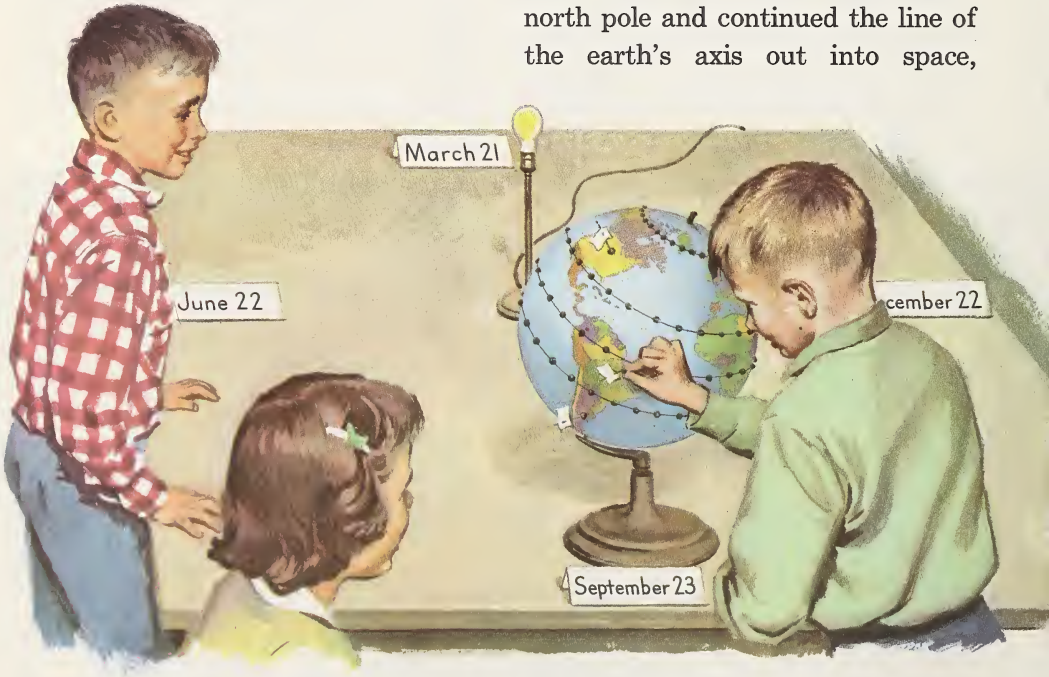
First, form the clay into tiny balls. Each ball should be only about $\frac{1}{8}$ inch in diameter. You are going to need a great many of these small clay balls to fasten on the globe. Place 24 of the tiny balls on the globe around the Arctic Circle. Space them equal distances apart. Then place another set of 24 balls around the Tropic of Cancer. These balls will be farther apart than

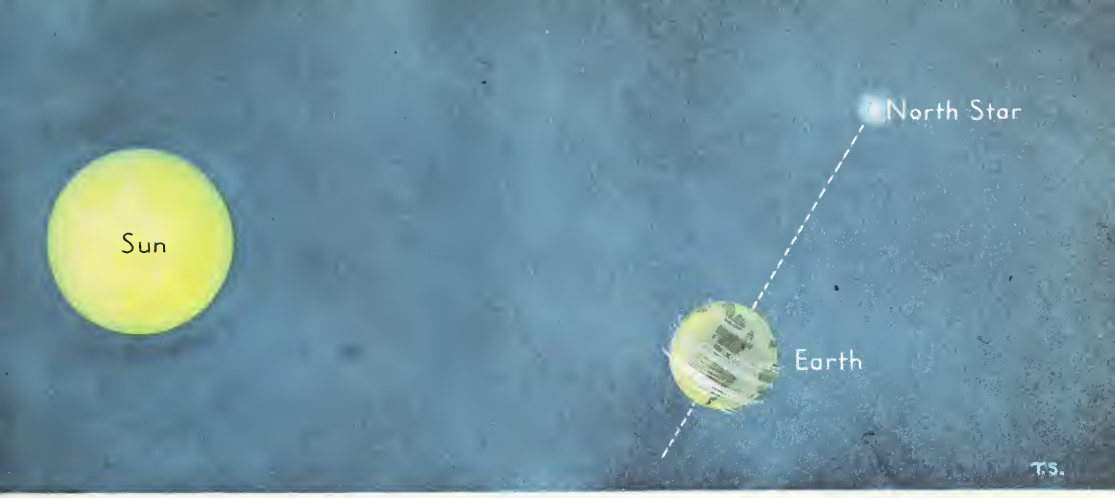
those around the Arctic Circle, but they should be at equal distances from each other. In the same way fasten other sets of 24 balls to the globe around the equator, the Tropic of Capricorn, and the Antarctic Circle.

You might place three markers on the globe to show the correct locations of Omaha, Belém, and Buenos Aires. You can make the markers by cutting out three small paper flags. If you put one end of a toothpick through each paper flag and the other end in a small ball of clay, the clay will hold each marker in place on the globe.

Now make four labels out of cardboard. The labels should read: December 22, March 21, June 22, September 23. Put an electric light in the center of a table. The light will represent the sun. Arrange the labels around the light just as you see them in the picture below. Now place your globe in the September position. Look at the picture again. Do you see the direction in which the globe is tilted?

You probably know that the north pole and the south pole of the earth are opposite ends of an imaginary line called the earth's axis. As the earth spins, it turns about this imaginary line. If you started at the north pole and continued the line of the earth's axis out into space,





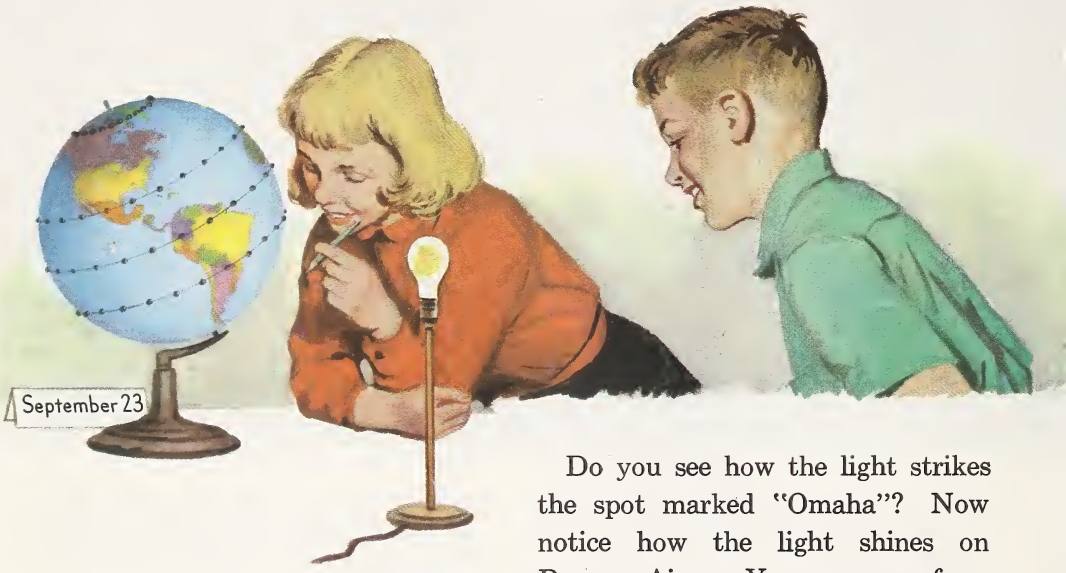
it would point toward the North Star, or polestar. All year long, as the earth journeys about the sun, the line of the earth's axis tilts toward the North Star.

When you have correctly placed your globe in the September position, the axis of your globe will be pointing toward an imaginary North Star. Wherever you move the globe about the light which represents the sun, its axis should continue to point in this same direction.

Now darken the room and turn on the light on the table. Check to see whether half the clay balls on the globe are lighted. You may need to raise the light by placing it on some books so that it will be on a level with the equator of the globe. If the balls have been correctly placed, and the light is at the right height, about sixty of the balls will be lighted at one time.

You know that as the sun shines on the earth, half the earth is always having day. All year long, part of the earth is turned toward the sun, and part is in the shadow we call night. Half the earth is always lighted, but the lighted half is constantly changing. You might try turning your globe part way round on its axis and again counting the number of lighted balls. Does the number stay the same?

Now you are ready to learn more about the movement of the earth around the sun. This demonstration will help you to understand how sunlight falls on the earth throughout the year.



September 23 Everywhere

On September 23 sunlight strikes the earth in much the same way that the electric light shines on the globe in your demonstration. Notice how brightly the equator is lighted. Does the light spread out equally north and south of the equator?

Look at the north pole and the south pole. Both these places are getting light from the sun. On September 23 there is light from pole to pole.

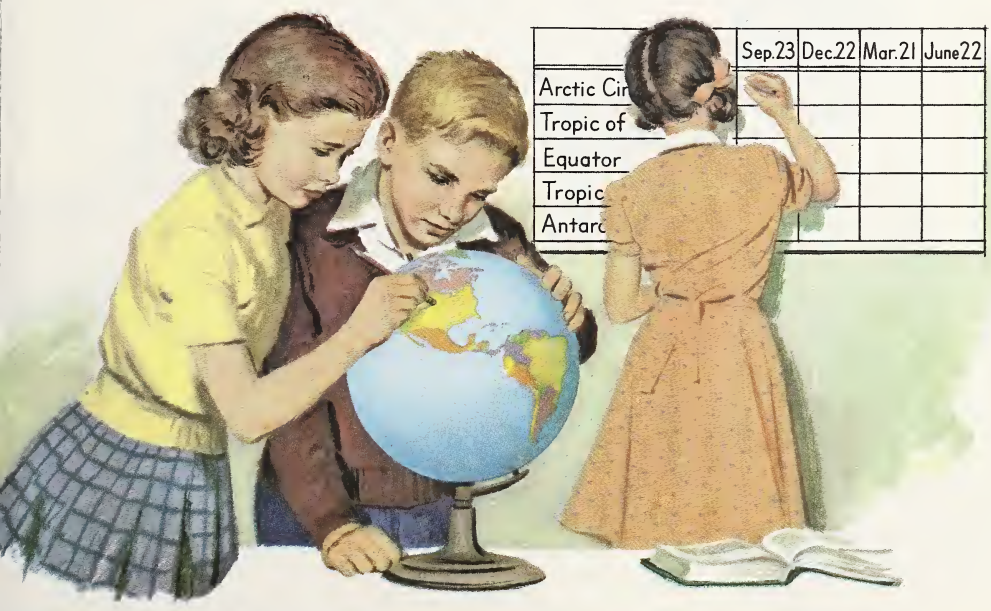
At Belém it is very warm, but the temperature is lower at the poles. The light spreads out more there than at the equator.

Do you see how the light strikes the spot marked "Omaha"? Now notice how the light shines on Buenos Aires. You can see from your demonstration that both places receive almost the same amount of light in September. The light and heat energy spread out a bit more in Omaha than in Buenos Aires because Omaha is a little farther away from the equator. The amounts of light that the two places receive are so similar that it might make you think that the season would be the same in both. The days are quite warm and sunny in Omaha, as well as in Buenos Aires. In Omaha, however, September is the beginning of autumn, and winter will soon be on the way. In Argentina September is the beginning of spring, and the warm days of summer lie ahead.

But there is one thing which is the same on September 23 at all three spots which you have marked on your globe. Belém and Omaha and Buenos Aires have the same number of hours of daylight and of night. In fact, on this date the hours of daylight and of darkness are about of equal number everywhere on the earth.

You can check the number of hours of sunlight in the day on September 23 by counting the number of clay balls that are lighted in each set on your globe. You know that there are 24 hours in a day, and there are 24 clay balls in each set. The number of balls lighted in each set will be about the same as the number of hours of sunlight in the day in each region.

It will help you to compare September 23 in different parts of the earth with other times in the year if you record your observations on a chart. Look at the illustration below to see how your chart might be made. You might even make one large enough to hang on the wall. At the side of the chart you will want to list the locations of the earth that you are observing: Arctic Circle, Tropic of Cancer, Equator, Tropic of Capricorn, and Antarctic Circle. Across the top of the chart you will need these dates: September 23, December 22, March 21, June 22.



Count the number of lighted balls in each of the five different locations on the globe. Record each number on the chart below the September 23 heading. How do the five numbers compare with each other? Do you see that they are about the same for all five regions of the globe? About half the balls in each set are lighted. This shows you that days and nights are of about equal length all over the globe on September 23.

How the Earth Moves

As the earth moves onward in its journey around the sun, some parts of the earth receive different amounts of heat energy than they did in September. Also, days and nights do not continue to be of equal length. Your demonstration will help you to see how this happens.

Move your globe to the December position. Be sure to keep it tilted in the same direction as before. Notice the way that the light now shines on the globe. Do you see that although you have not changed the tilt of the globe, the tilts of the Northern and Southern Hemispheres have changed? In September neither pole tilts toward the sun, but in December this is not so.

Look at the Southern Hemisphere. How brightly the light shines on this part of the globe! On the earth

south of the equator spring has given way to summer. Around Buenos Aires the crops are ripening in the fields. The days have become so warm that it is pleasant to sit in the shade or to go for a cool swim.

See how the light shines on the globe at the south pole. Are all the clay balls around the Antarctic Circle lighted? How many hours of daylight does this mean that there would be here on December 22?

Now notice how the light shines on the equator. This region still seems to be as brightly lighted in December as it was in September. There day and night are still about equal. The season has not changed.

North of the equator, in the Northern Hemisphere, you will find a different story. This hemisphere tilts away from the sun in December. The light spreads out more. This means that the sunlight does not produce as much heat energy here. The days are becoming cold and wintry. In Omaha there may be snow on the ground. There are no leaves on most of the trees. The children wear heavy clothing in order

to keep warm. There in December autumn is over, and winter has begun.

Look again at your globe and, as before, count the number of clay balls that are lighted in each of the five sets. Record the numbers in their proper places on your chart and compare them with your previous figures. You will probably find that none of the clay balls around the Arctic Circle are lighted on December 22. If you lived in these regions, you would not see the sun at all on this date. It would be so dark that it would be like night all through the day.

How many balls in all do you see lighted? Do you find that the light is still shining on about half of all the balls on the globe? The amount of sunlight shining on the earth has not changed in December. But different parts of the earth now receive different amounts of light and heat energy from what they received before.

Because the earth is tilted, there are more hours of daylight south of the equator in December than there are in September. At the same time there are more hours of night and fewer hours of day in the Northern Hemisphere. Because of the earth's

December 22 in the antarctic regions

tilt also the sunlight in December spreads out more above the equator than below. As the sunlight spreads out, it produces less heat energy. Does this help you to see how there can be short, cold, winter days in Omaha at the very same time that people in Buenos Aires are enjoying the long, warm days of summer?

Still keeping your globe tilted in the same direction, move it to the March position. Again observe how the light falls on different parts of the globe. Count the number of clay balls that are lighted and enter the figures on your chart.

You will find that days and nights are about equal everywhere on the globe in March, as they were in September. In March also neither hemisphere is tilted more than the other toward the sun. Places north of the equator receive about as much light and heat energy in March as those the same distance south of the equator. But again the seasons are different.

You remember that December was a time of higher temperatures in the Southern Hemisphere and of lower temperatures in the Northern. As the months change from December

to March, the temperatures rise in the Northern Hemisphere while they are dropping south of the equator. Even though in March the temperatures of both hemispheres are becoming somewhat the same, the seasons are different. This is because the weather in one hemisphere is moving from a period of warmth to a cooler time while just the opposite is happening in the other hemisphere.

Move your globe to the June position and again notice how the light energy concentrates in some parts of the globe and spreads out in others. Count the number of clay balls lighted in each place. What would the seasons now be in Omaha and Buenos Aires?

The Seasons Change

We have seen that as day follows day throughout the year, the seasons in the Northern and Southern Hemispheres are different. While it is autumn in one hemisphere, it is spring in the other. This is true of summer and winter also. Yet at the equator at sea level the temperature hardly varies at all from month to month. Here there is no summer nor winter, spring nor fall.

Do you see now how all this is possible? You remember that the north pole of our earth is always tilted toward the North Star. As the earth travels about the sun, however, sunlight strikes our tilted earth in varying ways. At the equator there is

hardly any change. The amount of heat energy from the sun varies when the light spreads out in the Northern and Southern Hemispheres. The numbers of hours of daylight vary also. The seasons change as first one pole and then the other is tilted toward the sun. Autumn, winter, spring, and summer—one season follows another because the earth is tilted as it makes its yearly trip around the sun.

LEARNING MORE ABOUT SEASONS

1. How does seasonal change affect what we do? You might list some activities that are affected by seasonal change.

2. Have one of your friends measure your shadow at nine o'clock in the morning, at twelve o'clock noon, and at three o'clock in the afternoon. Observe the size of your shadow. When is it the longest? When is it the shortest? Where does the sun seem to be for each of the shadows you made?

After a month repeat the making of your shadow. Your shadow should be measured at the same times during the day as before. Do you observe a difference in the length of your shadow? What makes the difference? During which season would your shadow be the longest? the shortest?

3. To find out that the hours of sunlight change from one day to another, you can do this: keep a record of the time the sun rises and sets each day. If the sun rises before you get up in the morning, you can probably get this information from a newspaper, radio broadcast, or television program.

Why are the hours of sunlight less each day in autumn in North America? Why do the hours of sunlight increase here each day during spring?

4. Explain why the sun seems to rise in the east and seems to set in the west each day.

5. Choose a city in Europe and a city in Australia and make a chart showing what seasons each would be having during March, June, September, and December.

6. Observé where the sun rises and sets in the sky one day each week for several months. Does the position of the sun in the sky seem to have changed? Why?

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Energy and Plant Growth

Plants and Sources of Energy

Did you ever think that there is quite a bit of energy locked in a tiny seed? In the picture you can see a sunflower plant which has grown from a seed planted in a garden. The children who are caring for this plant are keeping a record of its growth. They have found that it has grown over $1\frac{1}{4}$ feet in a month. It takes quite a "push" for a plant to grow so high so quickly.

You might record the growth of a sunflower plant, just as these children are doing. A sunflower will grow in a pot indoors if it is kept in a sunny place. First, plant a common sunflower seed about 1 inch deep in soil. Then press the soil down firmly over it. You might say that there is a double lock on the tiny plant inside the seed. The plant is locked in the seed, and the seed itself is held down by the weight of the soil pressed firmly above it. But if you keep the soil damp, the small plant will split the seed open and push its way up through the soil in a matter of days.

The energy for the beginning growth and push of the plant comes from food stored inside the seed. But the plant could not keep on growing unless it was able to

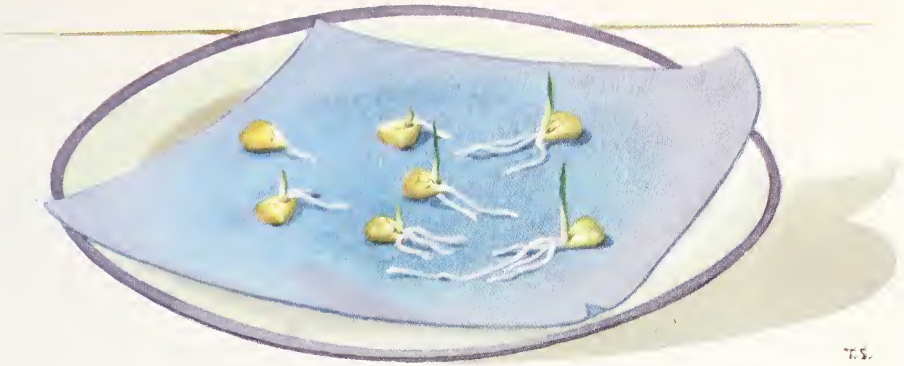
manufacture more food. This is used by the plant to supply chemical energy for further growth.

In order to manufacture food, the plant must have a source of energy outside itself. This energy is supplied by the sun. If the right conditions prevail, the plant inside a sunflower seed may supply itself with enough chemical energy to grow 10 or more feet tall.

It is interesting to observe a full-grown sunflower plant in bloom. You can see how sensitive it is to sunlight. All day long the blossom slowly turns to face the sun. As the sun sets, the sunflower will be facing west. It will face west throughout the night. But at sunrise it will swing back to the east to face the rising sun.

Like other green plants sunflowers make use of the sun's energy to manufacture food in their leaves. But light energy is not all that plants need. In fact, in most cases no light energy reaches seeds when the tiny plants inside them first begin to grow. It is dark down in the soil where seeds are planted.

What starts a plant growing from a seed? Your class might like to have a discussion about this.



Plant Growth and Water

Water is needed by plants to manufacture their food. Water does not supply the energy for plant growth directly. But without water plants would not be able to manufacture their energy supply.

More than 70 per cent of the weight of certain plants is made up of water. Seeds also contain water, although the water present in seeds may fall as low as 10 per cent or even less. The young plant in a seed will not start to grow until additional water is provided for it.

Water Enters the Plant

How is water taken in by the tiny plant inside a seed? You might try an experiment to see how seeds begin to grow. Put some kernels of corn on a piece of blotting paper in a dish. Keep the blotting paper damp and watch the seeds from day to day. Soon you will see that the kernels have split open and tiny roots have appeared. Later the rest of the plants will begin to develop.

Plants take in water through their roots. In most cases the water that plants use comes to them from the soil. Their roots extend down into the soil and draw water from it. Water is not taken in by the whole roots, however. There are certain little extensions on roots through which water enters. These are called root hairs. They are thin tubes, closed at the free end, and are capable of absorbing water through their surface. The length of root hairs varies. Some are quite small. Others may be as long as $\frac{1}{4}$ inch.

Often when a plant is dug up and replanted in another spot, the root hairs are destroyed. The plant will wilt and may die because it will not be able to take in water. But as you have probably noticed, the wilted plant may "pick up" again. This happens as new root hairs are formed. The freshly-grown root hairs allow water to enter the plant again.

Root hairs do not live very long, even on a plant which is not moved or disturbed. Each root hair works well for only a few days or weeks. Then it is no longer of any use to the plant. It shrivels and dies. But new hairs are always being formed by the plant as it grows. In this way there are enough root hairs to keep a good supply of water moving into the plant.

Some plants have roots that grow deep down into the soil. The roots of other plants are near the surface. There are examples of both kinds of roots among the many plants that grow in deserts.

Desert soil usually contains very little water. Some desert plants, such as mesquites and yuccas, have long roots, which reach down to water that may be deep underground. The roots sometimes grow to be 40 feet long. Many cacti have roots that spread out just below the surface of the soil. These plants can get water quickly when showers come.

Roots Take in Minerals

In addition to water there are other materials which enter plants through their root systems. These materials are called mineral elements. They are found in good topsoil and are necessary to plants for proper growth. Without them a plant may develop so poorly that it will die.

Scientists do not always agree which mineral elements are most needed by plants. There are seven of these elements that most scientists consider very important. These are

potassium, calcium, nitrogen, iron, sulfur, phosphorus, and magnesium. There are other minerals that may be as important in the growth of healthy plants, but plants need only very small amounts of each.

Each mineral is important to a plant in a particular way. For example, there is magnesium in chlorophyll. Chlorophyll is a chemical in the leaves of plants which they use in manufacturing food. Without magnesium a plant would have no chlorophyll and would not be able to make food. So a decrease in magnesium would mean a decrease in the amount of energy a plant has for growth.

Some of the minerals in soil dissolve in water. They are taken into plants with the water which the roots absorb. But plants take some minerals directly from soil. Their roots are able to dissolve minerals and take them in through the root surfaces.

Some children tried an experiment which helped to demonstrate that roots can dissolve mineral elements. A piece of highly polished marble was covered with about an inch of soil. Some bean seeds were planted in the soil and watered. As the bean plants developed, some of the roots came in contact with the marble.

The plants were allowed to grow for several weeks without being disturbed. Then the marble was removed and the soil washed from it. The appearance of the marble had changed. Where the roots had been in contact with it, they had left a pattern. This pattern was made as the roots dissolved the mineral elements of the marble.

The mineral elements found in soil are highly necessary to plants. But plants can be grown without soil if water and the necessary elements are supplied. This kind of agriculture is called hydroponics.

There are certain difficulties in hydroponic farming. As you know, when plants are grown in soil, the soil serves to support them. Without soil, plants must be supported in some way. Also, little green plants known as algae are apt to grow on the surface of the solution of water and minerals. Some method must be used to control the growth of these algae. One way of doing this is to cover the surface of the water so that sunlight does not strike it. Despite these difficulties hydroponics may prove to be a very useful way of producing large quantities of food in the future.

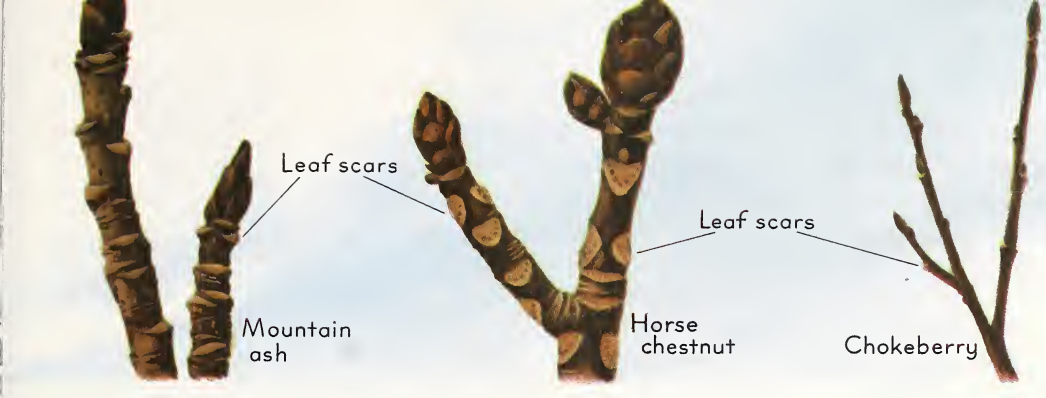
Leaves Give Off Water

Water passes through the root hairs and moves up through the plant. You might say that there is a stream of water moving through the plant from roots to leaves. In the leaves of the plant some of the water is used in the manufacture of food. Much of the rest of the water is given off by the leaves.

In late summer or early autumn many trees lose all their leaves. These trees are called deciduous. Cottonwoods, maples, elms, and birches are deciduous trees you may have seen.

Deciduous trees give off much water through their leaves. When there is little water that trees can use in the ground, the trees may lose too much water through their leaves.

Hydroponic farming



Autumn is the season of the year when the days begin to grow shorter than the nights. There is less light and heat energy. When less of the sun's energy reaches a region of the earth, the ground grows cold, and there is less water in the soil for trees to use. Perhaps you have never thought that plants must live under desert-like conditions when the weather is very cold.

When the ground is frozen, the water in the soil is in the form of ice. Plants can use water only in its liquid form. Of course they cannot take ice up through their stems.

Have you ever looked carefully at frozen soil? If you live in a place where the ground freezes in winter, try digging up some of the frozen soil. Or stamp on the ground with your feet. Does it feel hard?

You might try freezing some soil and examining it. Put some soil in a container that will go into the freezing unit of your refrigerator. Wet the soil well and leave it in the unit for several hours. Do you see any water that plants could use?

As times of lessened heat and light energy approach, the leaves of deciduous trees are dropped. A thin separation layer grows at the base of each leafstalk. It develops between the stalk of the leaf and the branch on which the leaf is growing. As soon as the separation layer is completely formed, it cuts off the supply of water, and the leaf drops.

There is no opening where each leaf has been. A layer of tissue grows over the spot where the leaf was attached to the branch. This spot is called a leaf scar.

You might like to examine the leaf scars on some of the trees and shrubs in your schoolyard or perhaps in a park. Leaf scars are easy to see on

Leaves of deciduous trees

twigs in the autumn, but you can see them at other times of the year also.

Probably you have seen some deciduous trees in your neighborhood that have not lost all their leaves in the autumn. Certain kinds of oak trees and other plants keep some of their dead leaves most of the winter. On these plants the separation layers may not have completely formed. Sometimes the veins which go from the twigs through the stems of the leaves may not have broken. The leaves usually fall off by spring.

Leaves of evergreens

Some trees stay green as long as they live. They never lose all their leaves at once. The leaves of some evergreen trees live for three, four, or more years. Some new leaves grow each year, and each year some of the older leaves drop off. It is possible for evergreen plants to lose some of their leaves at any time during the year because the separation layers may form at any time.

The leaves of some evergreen plants fall at regular times during the year. The white pine sheds many of its two-year-old or three-year-old leaves in late autumn. But there are always some leaves left on the plant.

Many evergreen plants have needle-like leaves. These plants lose less water than do most plants with broad

leaves. A live oak is an evergreen which has quite different leaves. Its leaves may be several inches long and up to 3 inches wide. They are not at all like pine needles. These leaves stay on the tree a year or longer. Then they turn brown and fall off. New leaves have already come out. A live oak has green leaves on it all year. Live oaks do not grow where the winters are severe.

Live oak

The surface from which water can go into the air is less in desert plants than in the large leaves of trees such as maples and oaks. The outside covering of the leaves of desert plants is harder and thicker than the covering of maple and oak leaves. These things help to make it possible for plants to live where there is very little water.

A plant called an ocotillo grows in some parts of the southwestern desert of North America. This plant has produced new leaves as many as eight times a year. When no water is available, the leaves turn brown and drop off.

Many desert plants have small, stiff leaves. The leaves of the creosote bush are hard and look as though covered with shellac. The leaves of some plants look waxy; others are covered with fine, short hairs. On some plants spines take the place of leaves. Water does not evaporate quickly from leaves like these.

Creosote bush

Ocotillo

Plants Use Energy

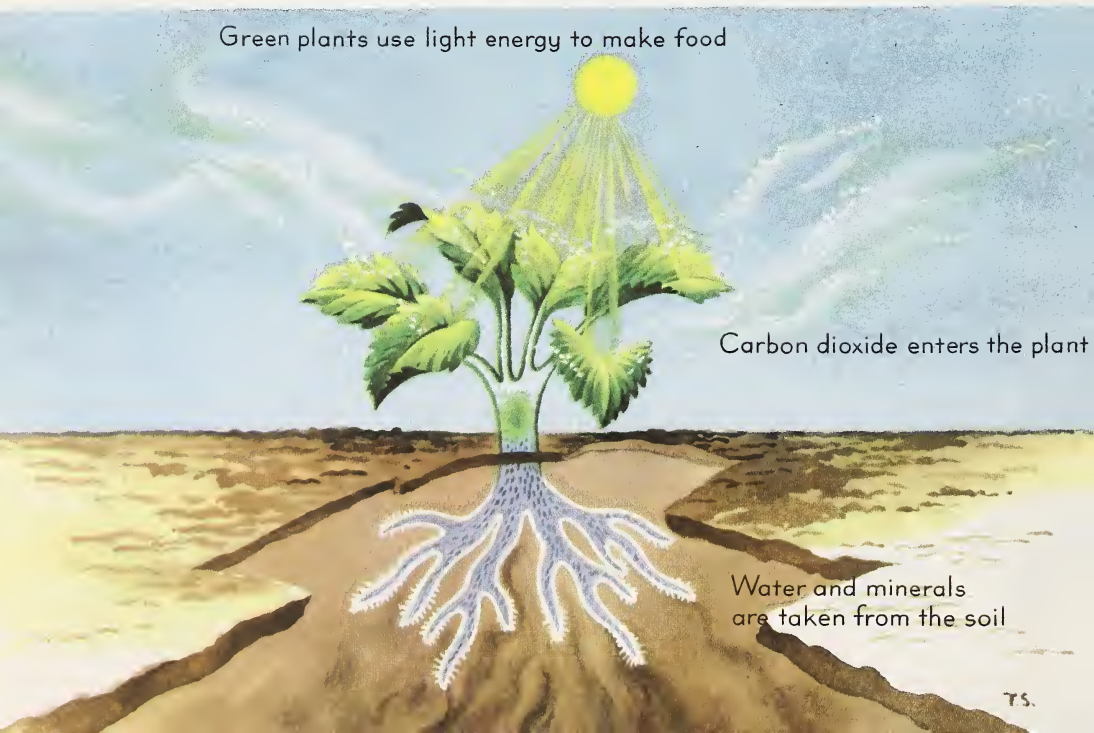
Energy from the sun provides light and heat through the year. Plants do not receive the same amount of energy from season to season. But we have plants in our gardens and fields year after year. Plants are able to make use of changing amounts of energy.

The hours of sunlight and the temperature make a great deal of difference to plants. Even the water that plants need for growth depends on the energy supply. Plants frequently need different amounts of energy to develop.

All plants and all parts of plants are affected by changing amounts of energy. Plants have many different ways of making use of changes in light, heat, and moisture.

Plants and Light Energy

All green plants need light energy. When sunlight falls on their leaves, these plants can make their own food. This is how we think it is done: Water with minerals dissolved in it is absorbed from the soil through the plant roots. The water passes through the stems to



the leaves. Carbon dioxide from the air enters the leaves of the plant. The water and carbon dioxide are changed into plant material by means of green coloring matter called chlorophyll. But wait! This change could not occur if there were not light energy striking the leaves. The energy of the sun falling on the leaves of the plant makes the chemical change possible.

The carbon dioxide and water are changed into a new chemical material, and the light energy is changed into chemical energy. The chemical energy now is a part of the plant. If you eat the plant for food, the chemical energy of the plant will be used by you as muscle energy.

You eat food so that you will have energy to play and work. Hunger is a sign that your energy supply is low. Why don't you just take a bowl of energy from the sun? You don't do this, because you cannot change light energy to chemical energy. Plants can do something that you can't do.

There are many plants which grow with little or no sunlight. These are the non-green plants, such as toadstools, mushrooms, puff balls, and other fungi. The non-green plants too use food to supply energy for growth. But these plants are not able to manufacture their own food. They must get food ready-made.

Some non-green plants attach themselves to green plants. They draw their food from inside the green plants. Others draw their food from the decayed parts of green plants and animals in the soil.

So you see, plants use light energy directly or indirectly. Green plants use sunlight to manufacture food for growth. Non-green plants use the chemical energy of green plants in order to grow.

The amount of light energy which is received by a region has a great deal to do with the kinds of plants able to grow there. The chart on this page shows the length of day at different places in North America on June 22. Notice how many more hours of sunlight there are on that day in Juneau than in Mexico City. The northern regions have more hours of sunlight each day during the growing season. This makes it possible for many plants to grow well in summer in the northern part of the United States and in Canada. From fifty to sixty days after some plants begin growing, they may be ready to harvest.

Hours of sunlight on June 22	
Juneau, Alaska	18¼ hours
Winnipeg, Canada	16½ hours
Seattle, Washington	16 hours
Salt Lake City, Utah	15 hours
Atlanta, Georgia	14½ hours
New Orleans, Louisiana	14 hours
Mexico City, Mexico	13¼ hours

Large crops of hay, wheat, and potatoes and other vegetables grow in some parts of Alaska. The many hours of sunshine each day during the summer help these plants to grow quickly. Harvest time is over before the frosts of autumn begin.

In the northern part of the Central Valley of California, oranges ripen faster than they do in southern California. In fact, the oranges are ready for market several weeks earlier than they are 400 miles farther south. This is partly due to the longer period of sunshine each day during the growing season.

Scientists have experimented with plants to find out how the length of day affects them. They found that some plants produce flowers and fruit only when the days are long. They are called long-day plants. In order to bloom, plants such as lettuce, radishes, and red clover need more than twelve hours of sunlight each day.

Other plants bloom only when the days are shorter, when there are

Arctic plants

fewer hours of sunlight. They are called short-day plants. Tobacco, soybeans, and ragweed are some plants that are short-day plants.

Many plants are neither long-day nor short-day plants. They will bloom when there are many hours of sunlight each day and also when there are few. People who study plants say that most plants probably belong to this group.

Plants and Heat Energy

In most places summer and winter temperatures are very different. On one of the coldest days of winter in Winnipeg, Canada, the temperature dropped to 41° below zero Fahrenheit. In summer on one of the hottest days the temperature rose to 107° F in Winnipeg. The temperature varied 148 degrees. What a great difference that was between the hottest and the coldest day of the year!

In Key West, Florida, in one year a difference of only 51 degrees between the hottest and the coldest day was recorded. In both Winnipeg and Key West the temperature of the air varied. But in Winnipeg the difference in temperature was much greater than it was in Key West.

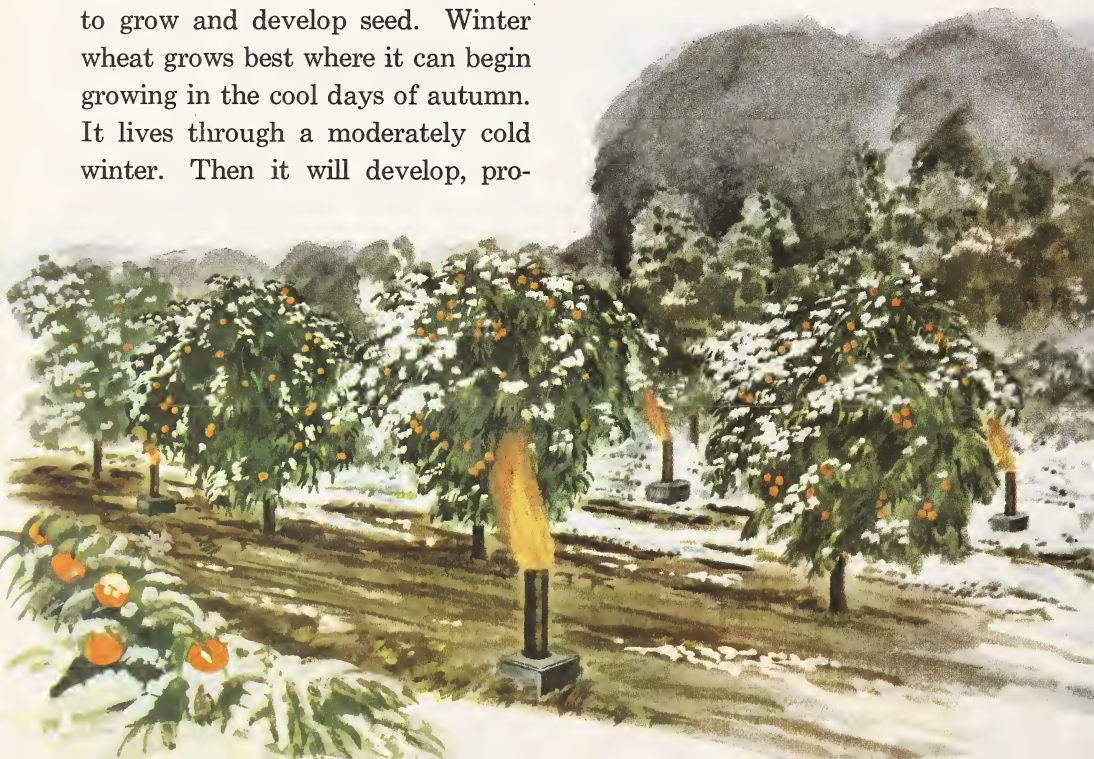
In other parts of the world there are other differences in temperature from one season to another. There are also many places on the earth where the temperature may change very little throughout the year.

Scientists have experimented with plants at different temperatures. They tell us that many plants can stand cold winter temperatures, but during that time they do not grow. In arctic regions some plants live through temperatures far below freezing.

Some plants can also stay alive when the temperature of the air becomes as high as 122° F. However, there is a certain temperature at which each kind of plant grows best. This means that although a plant may be able to live at a temperature just above the freezing point of water, it may grow very slowly. It may not be able to grow to its normal size. If the temperature climbed above 110° F, perhaps the same plant could not grow at all. At a temperature of 80°–90° F this plant may grow its fastest.

Oats, melons, and apple trees need quite different temperatures in order to grow and develop seed. Winter wheat grows best where it can begin growing in the cool days of autumn. It lives through a moderately cold winter. Then it will develop, produce seeds, and ripen in early summer before the heat of midsummer arrives.

Sometimes the temperature of the air changes very quickly. If this happens, plants may be injured. Perhaps you know of places where a sudden drop in temperature killed most of the blossoms on fruit trees. As a result there was little fruit in the autumn. In some places smudge pots are burned to protect the plants from quick drops in temperature that might kill the blossoms or injure the fruit. Plants may also be injured if the temperature rises very quickly.



Plants Continue on Earth

As far back as we are able to search in written records, we find that there have been plants growing. Many of our present-day food plants have been cultivated from the beginning of man's recorded history. Some plants have been cultivated since long before man was able to leave written records of their use.

All the plants which man learned to cultivate and care for existed originally as wild plants. In fact, we think that there were plants on the earth even before there were men. Plants have been on the earth a long, long time.

Think how important such plants as wheat, cabbage, oats, and carrots are to us. Then remember that man has been growing these plants for thousands of years. Cucumbers and onions have been cultivated for at least 4000 years. Rice has probably been grown for more than 6000 years.

How has the supply of rice, cabbage, onions, and other such plants kept up all through these thousands of years?

Some Plants Make Many Seeds

Certain plants grow, blossom, make seeds, and die within a short time. It is possible to grow these plants year after year because each plant makes many seeds. Inside each seed there is a young plant. The young plant can stay alive inside the seed for a long time. Each seed will grow into a new plant when the right amounts of moisture, heat, and light are provided.

When you plant seeds in your garden in the spring, you are planting seeds which were produced by plants during the long, warm days of the summer before. Perhaps you gathered the seeds from the plants yourself. Perhaps someone else gathered seeds from his garden and sent them to the store where you bought them.

Not all seeds are gathered and kept to be planted. Often many seeds fall to the ground. Sometimes these seeds are able to live through the cold of winter. The following spring they will start to grow.

To see this happen, you can try an experiment with a small amount of soil. Put about a cupful of soil in a glass jar and water it. In about a week's time you will probably see some small plants beginning to grow. Yes, there were seeds in the soil. They began to grow when enough heat energy and water were provided.

Plants Store Food

Some plants make seeds and store food in them. Some also store food in their underground parts. The first year, the young plants grow from seeds and develop leaves above the ground. Plants make food during the time when there is plenty of heat and light energy. This food is stored during the growing season in the underground parts of the plants. When cold weather comes, the parts of the plants that are above the ground may die. The underground parts remain alive, but in a resting stage. In this way the plants can live through the winter.

The next year, when there is enough warmth, water, and light, the plants begin to grow again. Later, flowers develop and seeds form. Even

if the plants die, new plants will grow from the seeds.

Certain plants store some of the food made during the growing season in underground parts called bulbs. Onions live through the winter months as bulbs. When the growing season comes again in the spring, the onion bulbs send up stalks on which may grow flowers and then seeds.

When a farmer wants to grow the green onions which we see in the markets early in the spring, he does not plant seeds. He plants small onion bulbs. These grow rapidly because food is stored in the bulbs. When the plants begin to grow, they use this stored food.

If you cut an onion bulb in half, you can see the new shoot in the center. Do you notice the thick leaves surrounding the shoot? These leaves are filled with stored food.

A white potato is made up of food which the potato plant stored in its underground stem. You can do an experiment to see how important this stored food is to the plant. Choose a potato with several well-developed eyes, or buds. You will need to cut three cubes out of the potato, each with a single bud. Make the sides of one cube $\frac{1}{2}$ inch. The sides of the second cube should be 1 inch and of the last cube 2 inches.

Now plant each cube in a separate, small flowerpot and mark the pots. Watch the size of the shoots which come from each of the three buds. Do you see how much larger the shoot is that comes from the bud with the most stored food?

Plants, such as trees, that live on year after year also store food in their stems, but their stems are

Lilac buds

not underground. There is much plant food stored in the trunks of trees.

Water is also stored by plants. Some evergreens hold water in their stems, or trunks, which the plants use when little water is available from the soil.

Many cacti are able to store water to be used when there is no rain. Some have water stored in their stems. There are other plants whose leaves are thick and protected by a tough covering. Water can be stored in these leaves. Perhaps you have seen a plant of this kind called hen and chickens.

Plants Form Buds

Plants that go into a resting stage must have some way of starting to grow again after the winter is over. During warm weather these plants make use of some of their energy to form buds.

Many deciduous trees and shrubs look as if they were dead during the winter, when their branches are brown and bare. However, the branches and roots of these plants stay alive all winter. When the first warm days of spring arrive, tiny green leaves and colored flowers appear on the branches. Where did the leaves and flowers come from? They were there all winter long. You did not see them, because they were tightly folded inside buds on the branches of the plants.

The buds on most trees are covered by scales which protect the leaves and flowers inside the buds from very cold weather. On some plants the bud scales are covered with fine hairs or a waxy substance. This covering protects the buds from losing too much water through evaporation.

You might like to examine the buds on a twig of a willow or a

maple tree or some other deciduous plant. Look at the buds on the sides of the twig. Do you see scales on the buds? Do the scales feel waxy? Are they covered with tiny hairs? Remove the scales very carefully and look at a bud through a magnifying glass. What do you see? If you see tiny, pale-green leaves, gently unfold one leaf after another. You are probably surprised to find so many leaves in just one bud. Notice that they are fastened to a very short stem.

Perhaps the bud you examined had no pale-green leaves in it. Instead, you discovered pale-yellow or pink petals. This bud is a flower bud. It too was formed the summer before.

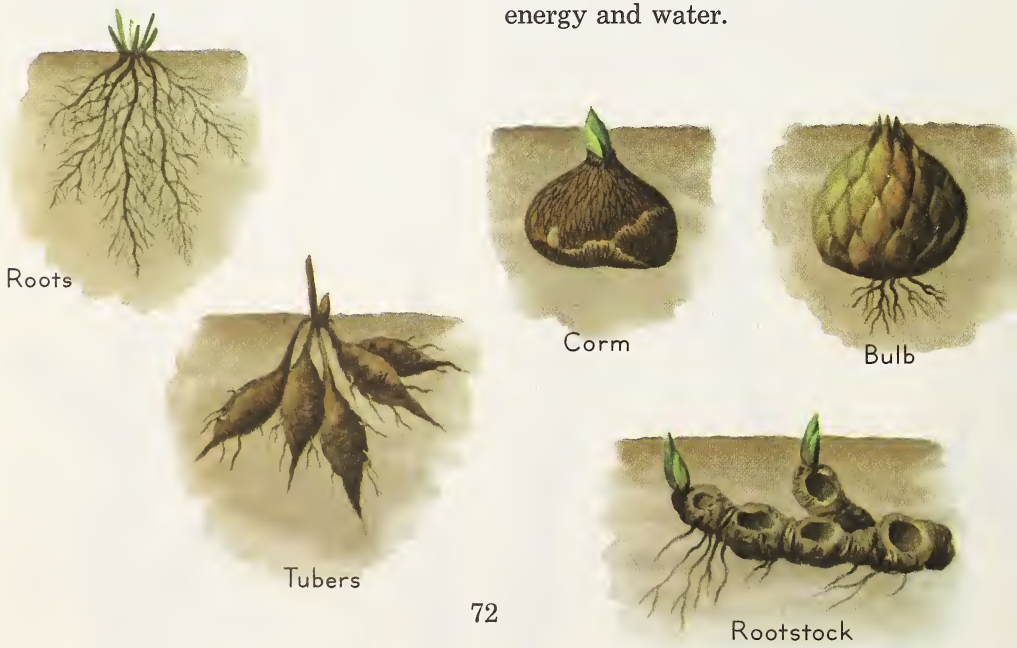
Here is something else you might do: In the late winter or early spring find a tree or shrub that has lost its leaves. Pick out a low branch so that you may look at the buds without harming the plant. It is best not to handle the buds. Look at the buds carefully. How are they arranged on the branch? Perhaps they are opposite each other like these shown in the drawing of a branch from a maple tree.

Some buds alternate on a branch. That is, they are placed one above the other on opposite sides of the branch, but no leaf is exactly opposite any other. The leaf buds of apple and peach trees alternate. On other plants, buds are arranged in a circle around each branch.

Some plants that live year after year do not have woody parts as trees and shrubs do.

Even plants that are not woody have buds which live through the winter. These are not the buds which you see above the ground. You do not usually see these buds for they are underground. On most of these plants the parts above the ground die when the cold days come. To live through the winter, the buds must be formed on the parts of the plants which are protected from the cold.

The underground parts of these plants are not all alike. However, they all live through the winter in a resting stage. They are called rootstocks, corms, bulbs, tubers, or roots. People commonly call them all bulbs or roots. They are protected against the cold air by the soil. Dry grass and leaves which cover the ground also help to protect them. Food is stored in these underground parts. The buds are formed on the rootstocks or bulbs or tubers or other underground parts of the plants. These buds allow the plants to grow quickly when they again receive enough heat and light energy and water.



Climates Change the Way Plants Live

In most places many different kinds of plants are in bloom during the summer. In desert regions, however, there is often so much heat and so little rainfall that few flowers may be seen during the summer months.

In a place such as the Hudson Bay region in Canada one can dig only a short distance during the warmest season before reaching ice and solidly frozen earth. There lichens, moss, small trees, dwarf shrubs, and many other small plants grow. There, too, the summer is so brief that in order to grow well, plants must be able to blossom and form seeds in a very few weeks.

If you live in the southern part of the United States, you may grow many of the same kinds of plants in your garden that boys and girls see farther north. However, many of your plants will grow differently. Some of the flowers and vegetables that grow well in northern regions will not grow at all where the weather is mild all year long.

You are probably familiar with the words *annual*, *biennial*, and *perennial*, which describe plants that live one, two, or more years.

Some plants, such as tulips and hyacinths, which are perennials in the north, must be treated as biennials in the south. New bulbs must be planted every second year in order to have these flowers. Still other plants that are annuals in the north are able to live on year after year in warm regions. This is true of tomatoes. In cool parts of the country these plants are annuals. They may become perennials in places which receive great amounts of energy from the sun throughout the seasons.

The southernmost part of the United States receives more energy from the sun all year long than places farther north do. This means that in some places there may be no frost at all during the year. Plants growing here have a long growing season and a short rest period.

Some kinds of perennials grow well where there is a long rest period each year. But they cannot live through a year-long growing season with hardly any rest at all. Lilacs and peonies are two perennials that do not grow well, if at all, where the weather is warm the year round.

You can see that the amounts of heat, light, and water that plants receive vary a great deal. They vary from one part of the earth to another and from season to season. Changing amounts of energy greatly affect the way that plants grow.

SOME THINGS TO THINK ABOUT

1. When people long, long ago first discovered seeds and how they could use them, their ways of living changed completely. They were able to live in one place instead of wandering in search of animals for food. Can you think of other reasons why the discovery of seeds and their use was important?

2. This is an experiment you can do with biennials that will take several weeks: Plant the whole roots of beets, turnips, and carrots in pots of soil. Label each pot with the name of the root you planted in it. Keep the pots in a sunny place and water the soil when it becomes slightly dry.

Watch your experiment carefully. After several days do you see some green shoots growing through the soil? After some weeks your plants may have flowers. Why?

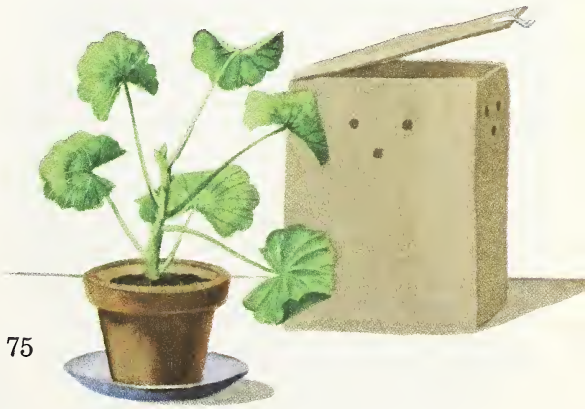
3. Some perennials, like the wild morning-glory, may become so thick that they are pests. Why is it difficult to get rid of these plants by cutting off only the stems and leaves?

4. Carefully cut one or two twigs from trees or shrubs. You may collect forsythia or willow or lilac, but do not cut more than you can use. Put the twigs in water. How do they look after several days? Do the buds all open on the same day?

5. Some plants are long-day plants, and others are short-day plants. How could this information help a florist to have plants in bloom all through the year?

6. You might try an experiment to help you understand what happens to the leaves of a plant when the hours of sunlight are lessened. You will need a cardboard box and two growing geranium plants about the same size. Punch several small holes in the box. The holes will allow air to get in. Cover one of the geranium plants with the box and leave it for three or four hours. Then remove the box from the plant for the remainder of the day. Do this to this same plant each day for a week. Give each plant the same amount of water each day.

Observe the leaves of the two plants carefully. Is there a change in the color of the leaves of one of the plants? If the leaves do not get enough sunlight to keep on making food for the plant, how do they look?



Animals and Seasonal Change

Changes All around Us

There is hardly a place in the world where there are no changes in the weather. Can you think of any place which does not have a change of some kind or another?

Of course you remember some of the changes that have taken place where you live each day, week, and month. We are all familiar with the change from a warm to a cold period and from rainy to sunny weather.

You might expect the weather to stay much the same day after day in the tropics. However, even here there are many changes taking place. There are many regions in the tropics that have long, heavy rains followed by periods of dry, dusty weather.

All the many changes taking place in the weather have an effect upon animals. We might say that when snow falls and the air cools off, some animals cool off also. At times animals are heated and at other times cooled, sometimes moistened and sometimes dried. There are many ways in which animals are affected by the changes taking place around them.

Energy through the Year

As you know, the changes we call seasons are brought about by the changes in the amounts of energy which reach different parts of the earth. In fact, many of the weather changes are the result of the way that the sun's energy reaches our tilted earth. Probably the most important change of all is the change in temperature.

Animals Become More or Less Active

Animals are affected by temperature in many ways. You may have noticed that on a cool summer morning flies usually are not very active. If the morning is very cold, the flies will tend to stay in one spot and not move around very much.

Here is something you might try: You will need a glass jar with a metal screw top. Make one rather large hole and several smaller holes in the cover of the jar. Wrap some cotton around a thermometer and insert it in the large hole so that the cotton holds the thermometer firmly in place. Now catch two or three flies without harming them. Then put the flies in the jar and screw on the top. The small holes in the cover will allow air to enter the jar.

Now you are ready for the next part of the experiment. Place the

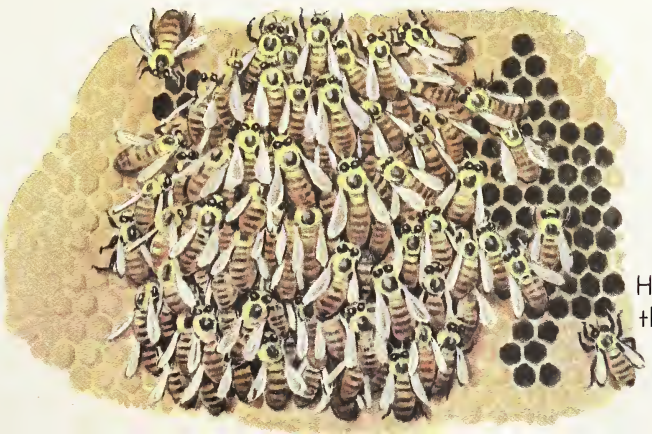
jar in a container of ice, as you see in the picture at the right. In a short time the jar and its contents will begin to cool. Observe what happens to the flies as the temperature is lowered. Do you notice that the flies become less active as the temperature drops? Now remove the bottle from the ice-container. Observe the activity of the flies as the temperature rises.

Not all animals act in the same way as the temperature drops. Some animals become more active, rather than less, when the temperature is lowered.

Probably you have been outdoors in cool weather when a sudden breeze sprang up. If your clothing was not heavy enough and you stayed in the breeze very long, perhaps you became cold and started to shiver. You may say that you became more active. The movement of your body which we call shivering is a way of producing heat to keep your body warm.

Honeybees in their winter groups are able to keep warm by being active. The bees, in a cluster, continuously vibrate their wings. Much heat energy is given off by all this muscle activity, and the hive is kept warm.

So you see that although some animals become less active as the temperature is lowered, others become more active. In fact, the activity helps to keep their bodies warm.



Honeybees in their winter cluster

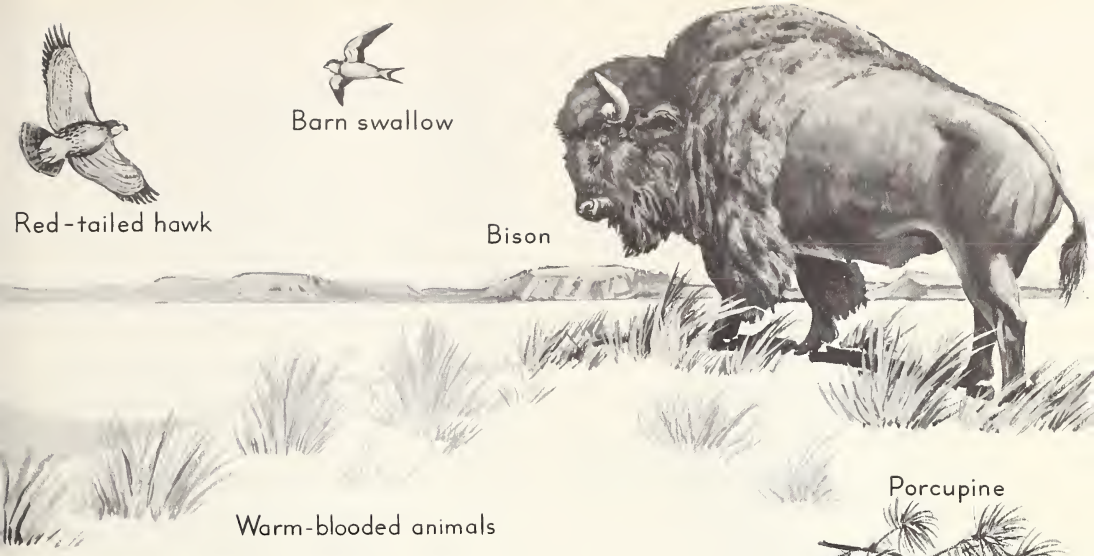
Cold- and Warm-blooded Animals

Winter is brought about by a decrease in the amount of the sun's energy received by a given region. This decrease causes lower temperatures. So the winter season is a cooler time of year.

Some animals are affected more easily than others by changes in air temperature. The temperature of some animals changes as the temperature of the air about them changes. These animals are usually called cold-blooded. When they are in a warm place, their body temperature is high. If they happen to be in a cold place, their body temperature will be low.

Snakes, flies, turtles, frogs, and many other animals are cold-blooded. During winter the body temperature of these animals is lowered. The temperature of these cold-blooded animals really varies with the amount of the sun's energy which reaches the place in which they live.

Cold-blooded animals

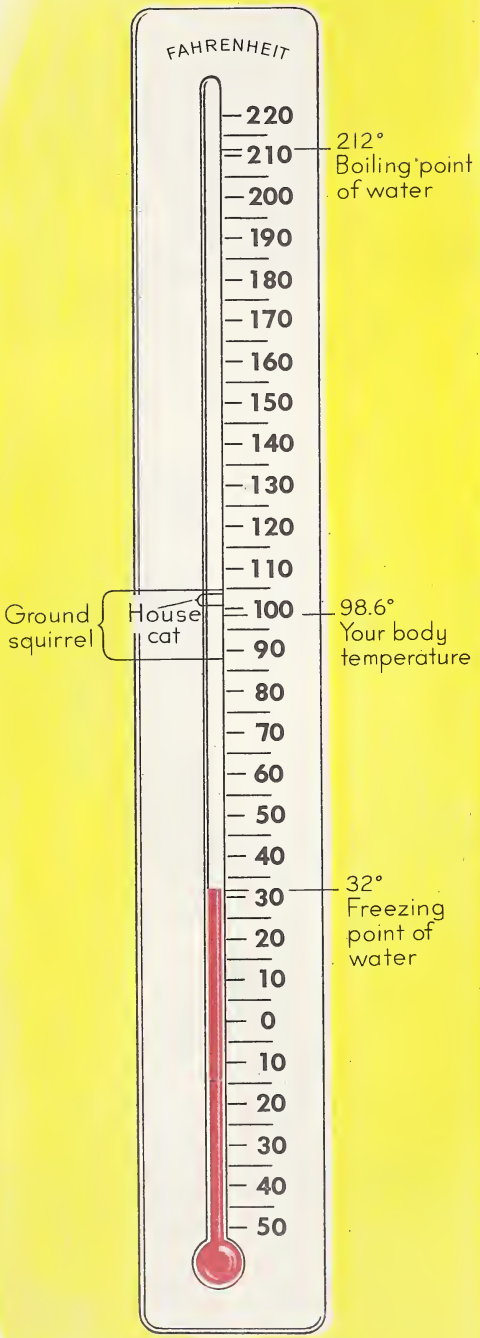


Warm-blooded animals

There is another group of animals, which maintain a rather constant temperature. These animals are called warm-blooded. The body temperature of warm-blooded animals remains at a certain point, even though the places in which they live may be quite cold.

Perhaps you have a thermostat on the wall in your classroom. You know that it automatically regulates the amount of heat in the room. You might say that there is something which acts like a thermostat in the bodies of warm-blooded animals. It regulates the amount of heat in their bodies and keeps them at a rather constant temperature.

Have you had your temperature taken recently? This is probably one of the first things your mother or the physician does to find out if you are sick. Perhaps someone has explained to the class the proper way of using a mouth thermometer. Once you know how to use a thermometer properly, you may be interested in checking to see what your own body temperature is.



Your body temperature is usually about 98.6° F. If your mother found that the temperature of your body was 101° F, she would know that you were sick. We usually say that a person with a temperature much above 98.6° F has a fever.

There is something within your body that regulates your temperature. When you become sick or something else happens to your body, your "thermostat" may not be able to work properly. Then your body temperature may go higher or lower than 98.6° F. This is a danger signal, and something should be done to restore your proper body temperature.

Birds, rabbits, squirrels, and deer are some of the warm-blooded animals. The temperatures of their bodies remain about the same during the different seasons.

The "thermostats" in the bodies of these animals may not regulate their temperature within a narrow range. The temperature of a healthy, active ground squirrel may be anywhere from 88° F to 105° F. This is a range of 17 degrees. As you can see, the temperature regulation of a squirrel is not too precise. The temperature of woodchucks during spring

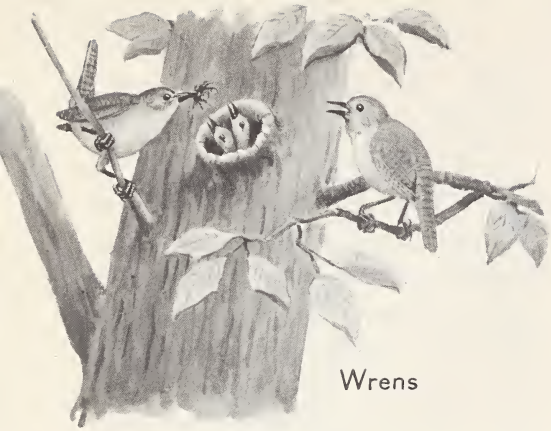
may vary from 94.8° F to 104° F. This is a variation of 9.2 degrees. The temperature of a common house cat may range only from 101° F to 104° F. The temperatures of warm-blooded animals do not rise or fall as the air about them becomes warm or cools. Though the ranges vary, all warm-blooded animals maintain a rather constant temperature within those ranges.

Winter Is a Difficult Time

To continue to live, animals need light, air, water, and food. During winter the amounts of water, food, and light may be decreased. Winter is a difficult time for most animals.

Supplies of food are almost always decreased during the winter season. All animals depend in some way on plants for food. Either they eat plants or they eat other animals, which depend on plants for food.

The most plentiful time of plant production is spring and summer. During winter most plants are in a resting stage. For example, the red squirrel can eat the flowers and seeds of box elder and striped maple during the spring. Then during the summer berries, mushrooms, and the roots of herbs will provide plenty of food. During the winter, however, the squirrel may have to depend upon his harvest of hemlock and pine cones or acorns from oak trees. As the seasons change from summer to fall to winter, it may become very difficult for an active animal to find enough food to keep alive.



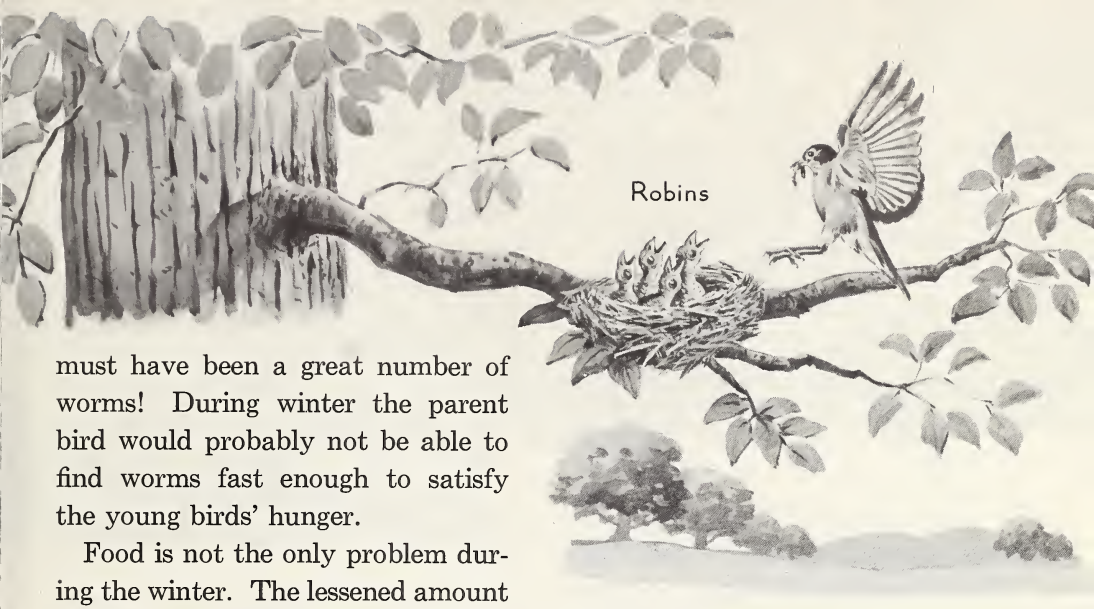
Wrens

Here is something you might do: Observe a nest of young birds during spring or summer. Notice how often the parent bird returns to the nest with food.

You will be amazed at the number of trips the adult bird makes to feed the young. The parent comes and goes so fast that it almost seems as though there were not enough time to hunt for food. We are told that one house wren made about twelve hundred trips to its nest in a little more than fifteen hours.

A feeding experiment was done with a young robin in the spring to find how much food it would eat. It was found that this robin ate 14 feet of earthworms in one day. That

Foxes hunt field mice at every opportunity. As winter comes on and snow falls, it becomes increasingly difficult for a fox to catch enough mice to satisfy his hunger. The fox may then turn to hunting pheasants. If it is a hard winter, the fox may even have to search through the snow in orchards for apples and other scraps of food which may lie covered.



Robins

must have been a great number of worms! During winter the parent bird would probably not be able to find worms fast enough to satisfy the young birds' hunger.

Food is not the only problem during the winter. The lessened amount of heat energy also adds to the difficulties of animals. Most animals live best at certain temperatures. If the air becomes too cold or even too hot, animals may die.

Many cold-blooded animals are killed when their body temperature is lowered to 32° F, the freezing point of water. Many places have temperatures during winter which fall far below this point.

So you see, during winter animals may come up against at least two serious difficulties. Food may become less plentiful, and there may be a drop in temperature. In order to continue to live, animals must be able to overcome these difficulties.

Living through Difficult Periods

As we know, animals do live through the difficult times of winter. There are many ways in which this is possible.

One of the most obvious things an animal can do is to leave the region where life is becoming difficult for it. Many animals do this. They journey to a region where the conditions of heat and food are right for them to continue to live. When the seasons change again, they return to the region from which they have come.

Mule deer

If animals stay in a region where they are going to meet difficulties, then some changes may be made. These may be changes in the animals' bodies and changes in their activities too. Some animals develop thicker coverings of fat, fur, or feathers. These coverings help to protect the animals and make it possible for them to live through the difficult period.

Also, if animals are going to remain in a region, they may go to a place where they are protected. They may go underground, into a tree trunk, under bark, or any other place which will give them protection. They will usually stay in the protected place until conditions are more favorable for them. All these things may make it possible for them to live through a period of difficulty.

Many Animals Migrate

When animals depart from and return to a region during certain seasons of the year, it is said that they migrate. There are a great many different kinds of animals that migrate. Some of these are herring, salmon, eels, certain whales, fur seals, mule deer, monarch butterflies, and a large variety of birds.

It is interesting that the monarch butterfly is one of the very few insects which truly migrate. Most insects do not migrate any great distance. But monarch butterflies may fly as far as from Canada to the southern United States and back again. Large swarms of these butterflies may gather in the northern

United States and in Canada in the early fall. As the butterflies fly south, they can sometimes be seen in late autumn in great swarms along the New Jersey coast. Small trees have been seen there in October completely covered with clinging masses of these butterflies. The butterflies spend the winter in the Gulf states and in the spring they migrate north again.

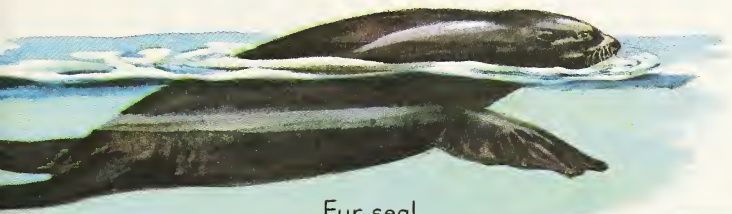
Many birds travel great distances each year. One of the best known of these is the American golden plover. The northern home of the golden plover is along the arctic coast of North America. Plovers arrive about the first week in June and build their nests in the moss on the ground. Young plovers are hatched and after several weeks the young birds are strong enough to fly. Then the long, southern migration begins.

The birds move slowly along the coast of Labrador. They feast on berries and grow fat. In this way they store energy for the long flight ahead of them. From Labrador they cross to Nova Scotia. Then they start out across the ocean for northern South America, 2400 miles

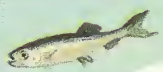
Golden plover

Monarch butterfly

Some migrating animals



Fur seal



Herring

Eel

Atlantic salmon

away. If you follow their route on a map, you will observe that golden plovers fly over Bermuda and other islands in the Atlantic.

Finally, in September the plovers reach their home in Argentina. They have traveled almost 8000 miles from their home in the north! Then about the beginning of March the plovers start northward again. Follow the arrows from the southern home of the golden plover to the northern home. Is it the same route that they took in flying to South America? No one knows just why the plovers fly northward by a different route. By early June the plovers reach their northern home again.

Another great bird traveler is the bobolink. Bobolinks spend the summer in Canada and the northern part of the United States. Here they make their nests and raise their young.

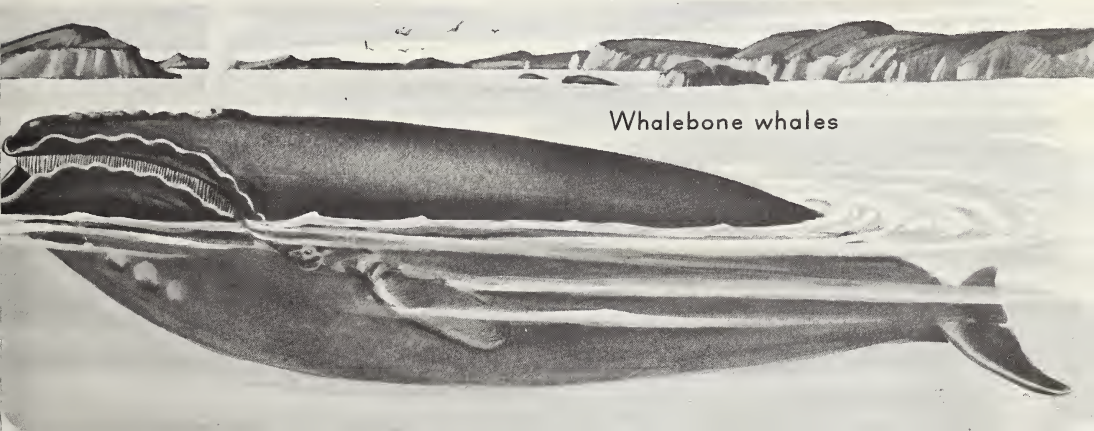
In the autumn bobolinks leave fields and meadows to begin their long journey southward. As they fly south, they stop in North and South Carolina. There they feed on the ripening grains of rice. Often they cause much damage to the rice crop. Bobolinks travel more than 4000 miles to reach their southern home in southern Brazil. They travel most of the way by night, stopping to rest and feed during the day.

Bobolinks

Why Do Animals Migrate?

One cause of migration is probably lack of food. Some of the whalebone whales migrate for this reason. As the seasons change, there are also changes in the temperature of the sea. During summer food is plentiful in the northern seas. At this time these whales may be found in the Atlantic Ocean around Newfoundland.

As winter comes on, the seas begin to cool. Then the food supply of the whales becomes more plentiful southward. As this happens, they begin a southward migration. During winter they can be found off the Carolina coast of the United States.



Whalebone whales

The energy from the sun seems to have an effect on nearly all animal activity. In the case of the whalebone whales it can be seen that the energy from the sun is really influencing the migration. It is the heating and cooling of the sea by the sun's energy that determine where food will be most plentiful. The whales migrate northward and southward to have a continuous supply of food.

Some scientists think that bird migration may be affected by the length of day. Much of their evidence points to the fact that certain birds begin migrating at a particular time of year. It doesn't seem to matter what the weather is like at that time or how plentiful the food is. The only condition that seems to be the same from year to year is the number of daylight hours when migration begins.

Changes in the length of day may bring about changes in the bodies of birds. Longer days may bring about changes which cause them to nest and breed. We know that it is during the longer days of June that some birds move north. Most migrating birds nest and bear young in their northern home.

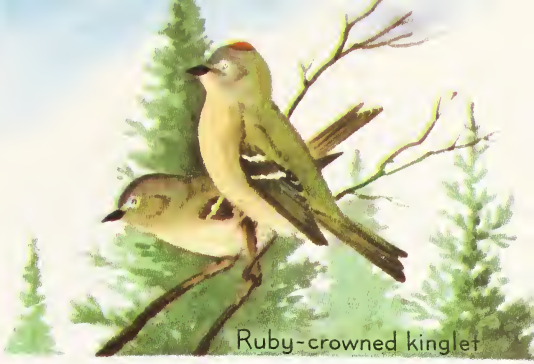
Another theory helps to explain why the birds go north to nest. Look at the continents in the Northern Hemisphere. Do you notice that their area expands toward the north? The continents in the Southern Hemisphere taper off toward the south. More nesting area is available toward the north during the long days of summer. The large feeding and breeding areas of the north may have led to the annual migrations of birds.

There are many other theories about why animals migrate. No one theory seems to explain all the things that are known about animal migration.

Migrating Uphill and Downhill

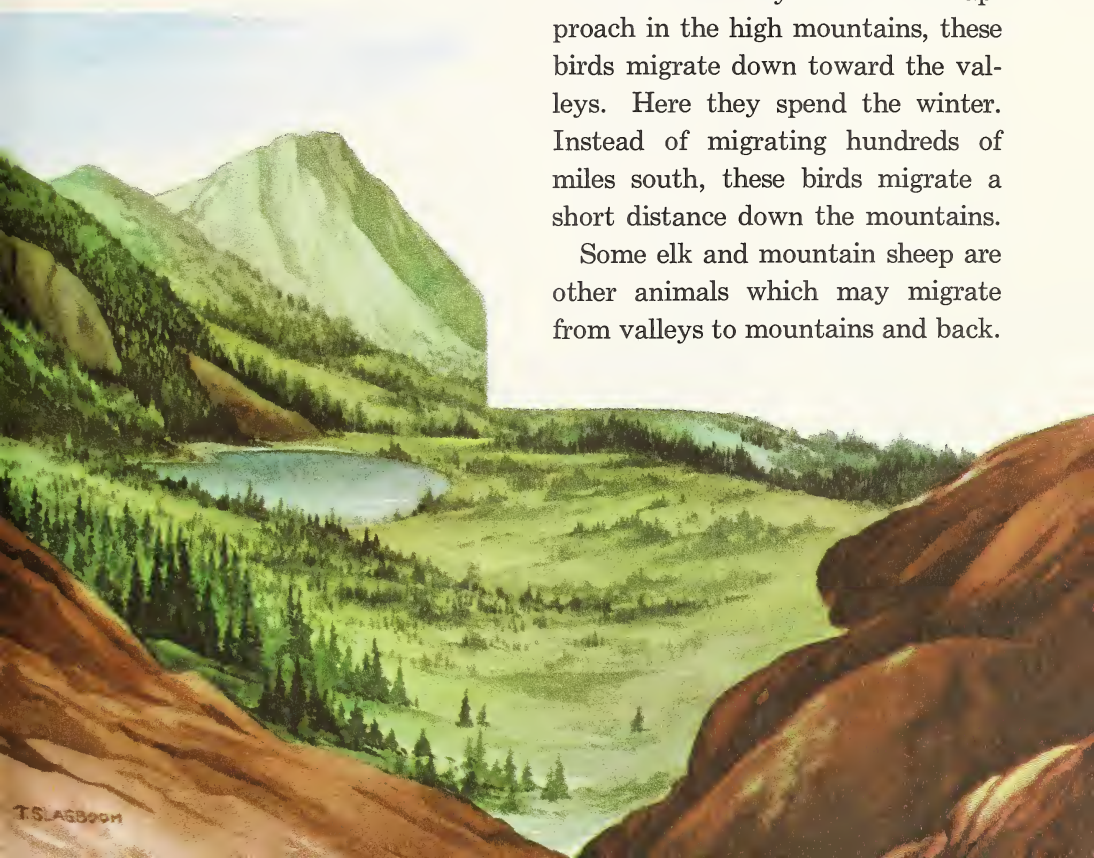
Did you know that some animals migrate by traveling up or down a hill or mountain?

On this page is a picture of the western ruby-crowned kinglet. This bird usually spends the winter in the valleys of California. In the spring it leaves the valleys and travels up the mountains. In the mountains the summer is much like summer in Canada. But the western ruby-crowned kinglet travels only a short distance from the valley to the nearest mountain. Six or seven thousand feet up, summer is much like summer at sea level a thousand miles farther north.


Ruby-crowned kinglet

As the cool days of autumn approach in the high mountains, these birds migrate down toward the valleys. Here they spend the winter. Instead of migrating hundreds of miles south, these birds migrate a short distance down the mountains.

Some elk and mountain sheep are other animals which may migrate from valleys to mountains and back.



Many Animals Hibernate

Another way in which some animals are able to live through difficult winter conditions is to hibernate. Hibernation has been called by some people "winter sleep." But it is not a true sleep. During hibernation animals remain in a protected place and become very inactive.

Many animals that hibernate are warm-blooded most of the year and have constant body temperature. But during hibernation the body temperature of an animal may be lowered. You might say that its "thermostat" is turned down when it begins its "winter sleep." This helps the animal to conserve its energy and fuel, so that it can live through a long winter.

An animal would freeze to death if its body temperature fell below freezing. Usually an animal will awaken if the air temperature in its winter home gets as low as freezing. But sometimes the animal continues to "sleep" as the temperature around it drops below freezing. Death comes to the animal as it slowly freezes. This is not uncommon, and many animals do not survive hibernation.

Perhaps you live in a region where the ground freezes in winter. If so, you might examine the soil in the side of an excavation that has been made during freezing weather. You will probably notice that only the soil near the top of the excavation is frozen. In some sections of the country the soil may become frozen

to a depth of only 18 inches. But at other places the soil may be frozen to a depth of 3 feet or more. You probably can find out how far down the soil freezes where you live.

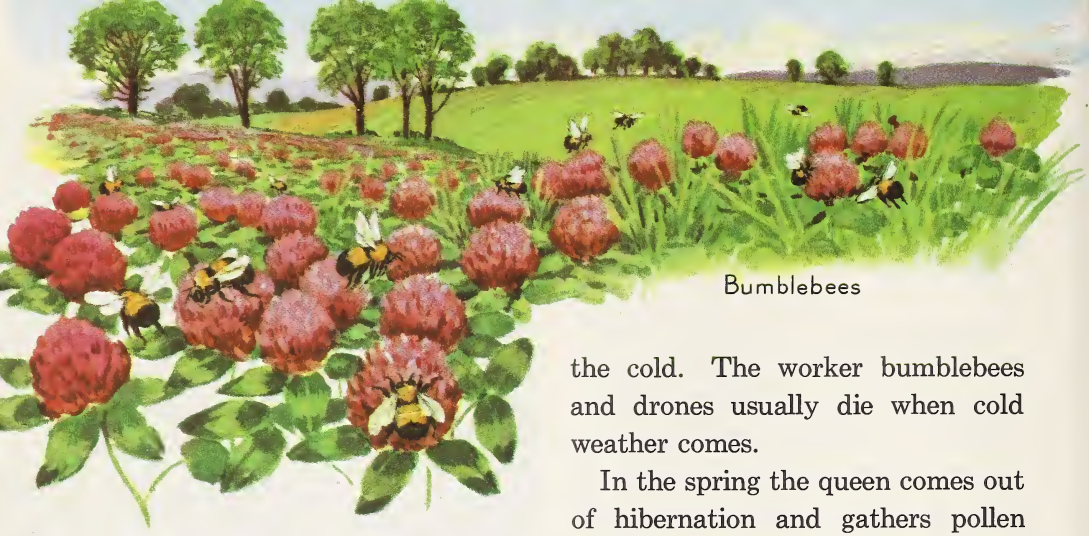
Many animals that hibernate spend the winter in caves or burrows in the ground. These holes or burrows are usually deep enough in the soil so that there is no danger of freezing. We usually say that the burrows are below the frost line. Woodchucks and toads are two familiar animals that hibernate below the frost line.

Woodchucks usually hibernate before the first severe frost. Food may still be plentiful then; so it probably is not lack of food which causes the woodchuck to begin its long "winter sleep."

Before autumn the woodchuck's body develops a thick layer of fat. By late September or early October woodchucks have disappeared from fields and meadows. Most of them have retired to burrows in the ground well below the frost line. These burrows are often lined with grass and leaves. Woodchucks usually remain in their winter homes about twenty to twenty-four weeks.

If we were to look in upon a hibernating woodchuck, we should find it rolled into a ball. The feet would be close together and rigid. The animal would appear to be frozen into a tight ball, with eyes and lips tightly closed.

A woodchuck is normally a warm-blooded animal. But the body temperature of a woodchuck during hibernation is usually about the same temperature as that of the place in which it has made its burrow. Since its burrow is usually well below the frost line, its temperature is probably slightly above the freezing point of water.



Bumblebees

Animals in Protected Places

Animals that hibernate must do so in places that will shield them from direct exposure to the cold of winter. Not all animals hibernate below the frost line during the winter months. Some animals hibernate in other places. It may be a hole in a tree, a hollow log, or a cave. It may be a burrow in the side of a grassy slope.

The queen bumblebee is an animal that hibernates in a protected place. She finds a dry place and digs herself a small nest. Often it is in the old burrow of a field mouse. Here she stays during the cold days of winter. In this way the queen is protected from direct exposure to the cold. The worker bumblebees and drones usually die when cold weather comes.

In the spring the queen comes out of hibernation and gathers pollen and nectar from the flowers. She makes beebread from the pollen and nectar and then lays her eggs. The first young that hatch from the eggs are workers. They do the work of gathering food. Before many weeks there is a full-grown colony of bees.

In the autumn, when the days grow cooler, some kinds of snakes crawl into holes or under logs. Others burrow into the soil below the frost line. There they hibernate until the following spring. Some snakes hibernate alone. Often many of them gather together in one place to spend the winter. Sometimes there are several dozen snakes in one place.

Some animals may awaken, search for food, and return to hibernation several times before spring arrives. On a sunny day in winter you may

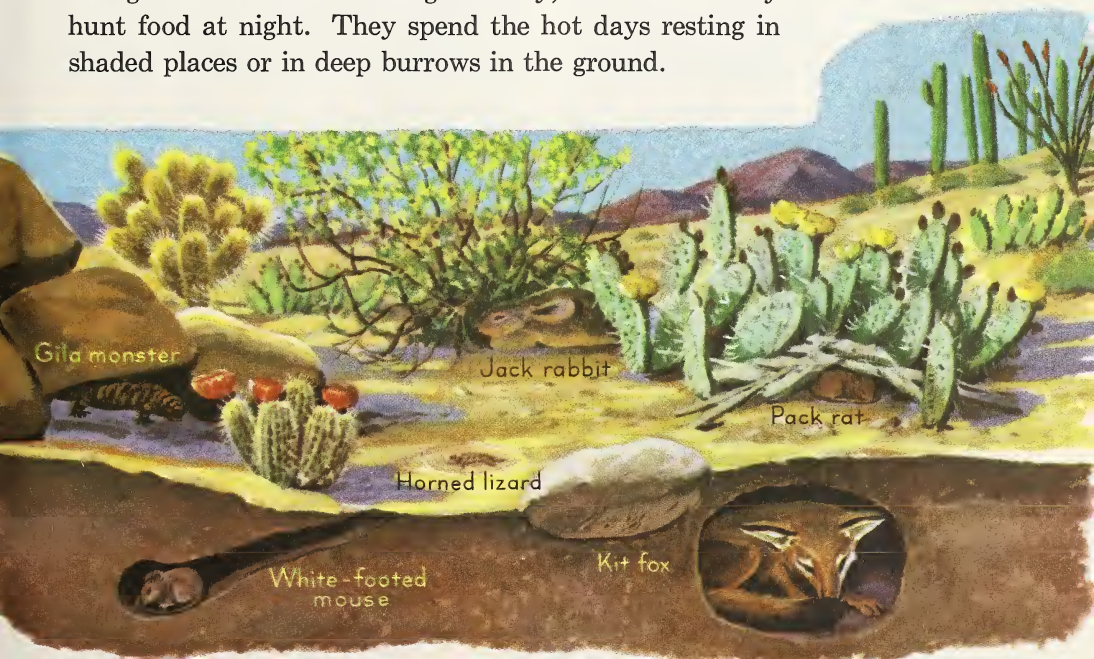
be surprised to see a squirrel scamper across your path. If you watch it, you may see the squirrel paw away the snow and dig into the ground. The squirrel is digging up some nuts that it buried last autumn. After the squirrel has eaten, it returns to its home in a tree. Here it stays during the very cold days of winter, hibernating.

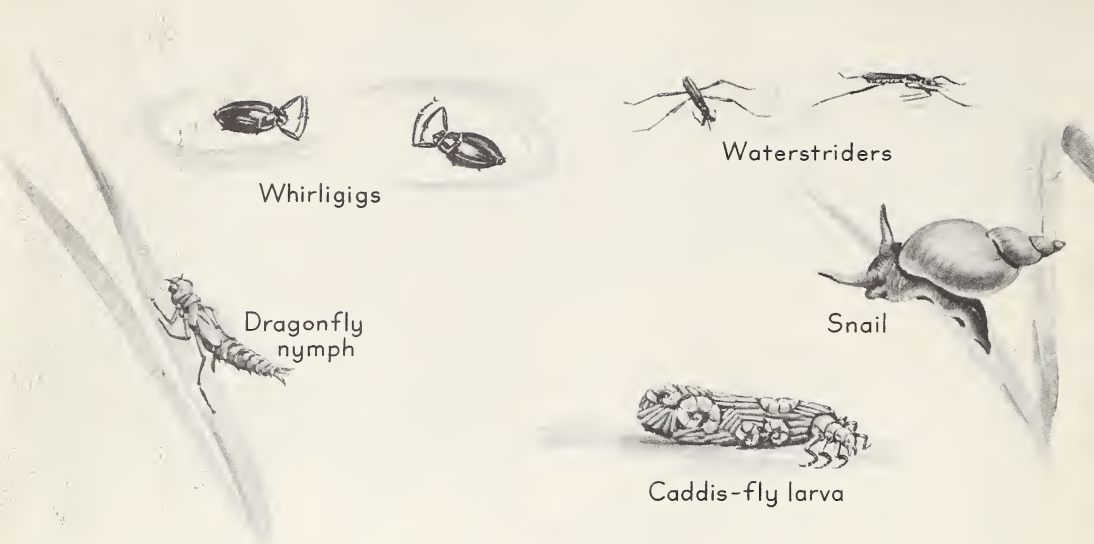
During any of the winter months when it is warm enough for the snow to melt, opossums may be found in the woods. These animals are searching for food. Then when the weather becomes cold again, they return to their winter homes in hollow trees. Here they remain until warmer weather may awaken them, and they again leave their homes in search of food.

Opossum

Animals during Dry Seasons

In some parts of the earth the dry, hot season is the most difficult time for animals to stay alive. Some animals that are usually active during the daytime change their habits. During the dry, hot season they hunt food at night. They spend the hot days resting in shaded places or in deep burrows in the ground.





Some snakes and lizards that live in deserts spend the day under rocks and bushes. At night, when it is cooler, they come out and hunt for food. The desert sunlight has too much heat energy for them. They are cold-blooded animals, and their body temperatures would be raised by the desert sun. If they remained in the sunlight, they might be heated too much and die. You might even say that they would be cooked by the sun.

Other animals remain inactive in protected places during dry, hot weather. Some snails are able to live through long periods of drought. They crawl into a protected place and make a substance which seals the opening to their shells. They remain inactive until the next rain. Then during the moist weather they live an active life again.

Sometimes ponds dry up during an unusually hot summer. Many of the animals living in these ponds bury themselves in the mud in order to stay alive. If you can find such a pond near where you live, get a shovelful of soil from the pond. Put the soil in a bucket or pan. Then add water to the soil. Do you see any living things swimming around? Look at the pictures at the top of this page. You might see some of these animals.

There is some kind of seasonal change during the year in almost all

parts of the world. Some of these changes bring a variety of conditions which make life difficult and dangerous for living things.

Each kind of animal has its own particular way in which it continues to live through periods of change and difficulty. We know that migration, hibernation, and changes in the bodies of animals provide ways in which animals rest and live through difficult times. But there is still much to learn. In the next few years we shall probably learn of many new discoveries about how and why these changes take place.

LEARNING MORE ABOUT ANIMALS

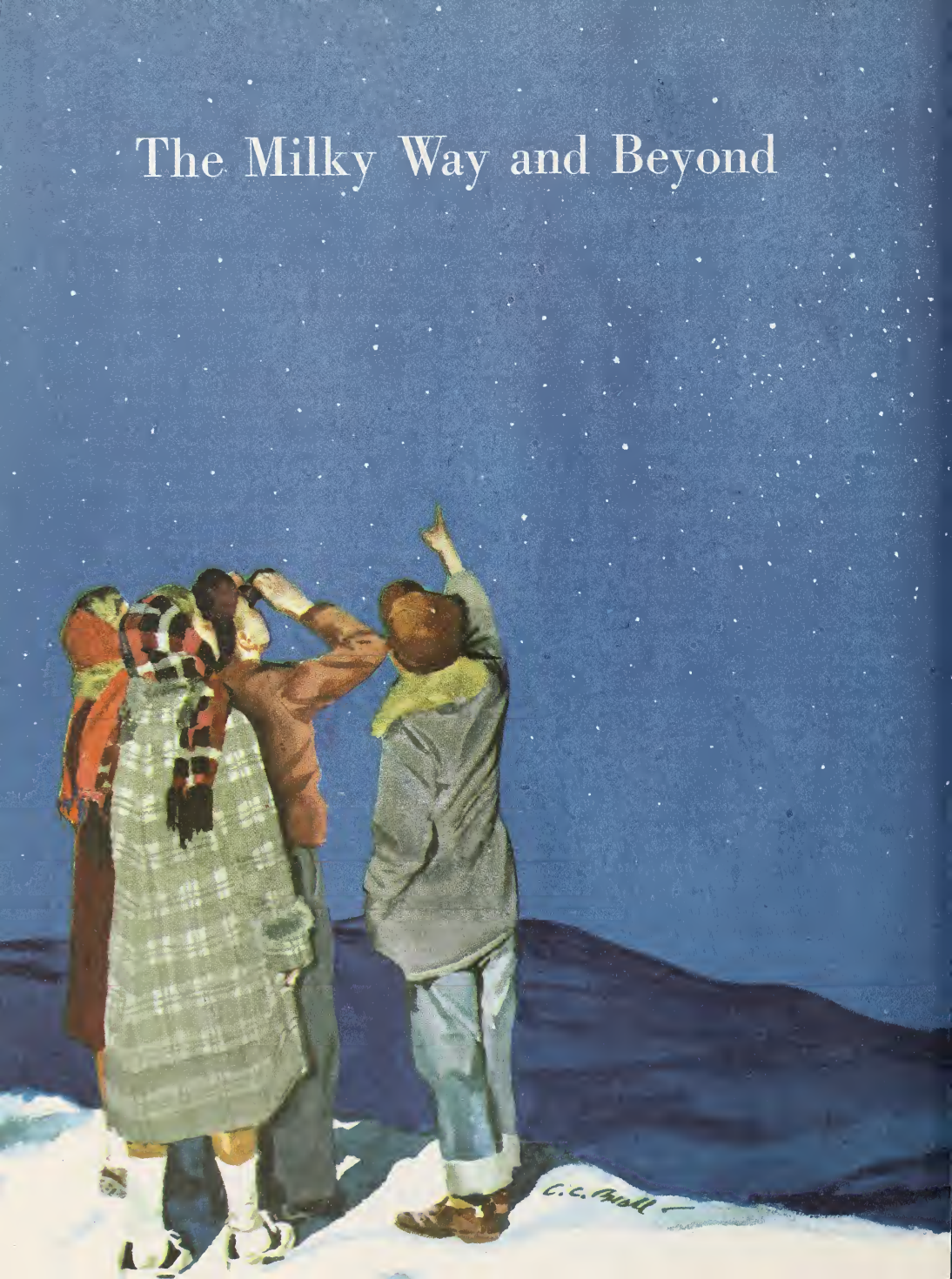
1. During autumn watch the animals in your neighborhood. What changes do you notice? Are some animals disappearing? You might keep a record of your observations.

2. Keep a record of the birds you see during each month of the year. You will discover that some birds come early in the spring and spend the entire summer in your community. These birds are called summer residents. During autumn these birds will probably leave your community and fly south.

Some birds spend only the winter in your community. We call these birds winter residents. They spend the summer farther north and migrate south to your community for the winter.

3. You might build a feeding shelf for birds in winter. It will be interesting to watch the birds that are winter residents in your community. Besides providing food for the birds, the feeding shelf will give you a chance to study them as they come to eat. What foods do they prefer?

The Milky Way and Beyond



What Is the Milky Way?

Perhaps you have been out in the open country on a clear, moonless night. If you have, you may have seen a wide band of pale-white light that stretches across the sky among the stars.

Because of its whitish color and appearance this band of light has been called the Galaxy. *Galaxy* comes from a Greek word which means "milky." Many ancient people thought of it as a kind of highway, and so it came to be known as a way. It was called the Milky Way.

The Milky Way may seem to begin on the horizon and stretch up over your head, across the sky, and down to the horizon behind you. As you look at it, you may ask, "What can it really be?" You know that there are stars, planets, and comets in the sky, but what is the Milky Way?

A portion of the Milky Way

You could get a better look at the Milky Way if you had a telescope to use. With a telescope you would be able to see that there are more stars in the Milky Way than anyone could possibly count. This band of light is really coming from millions and millions of glittering, sparkling stars.

You do not need a strong telescope to see that the Milky Way is made up of stars. Almost any pair of good field glasses, or binoculars, is strong enough.

If you are planning to look at the Milky Way, be sure to pick a clear night when the moon is not visible. You will be able to see more clearly if you are far from city lights. As you look through the glasses, you will see that this cloudy veil of light is made of a vast haze of stars. They seem to be very small and crowded together.

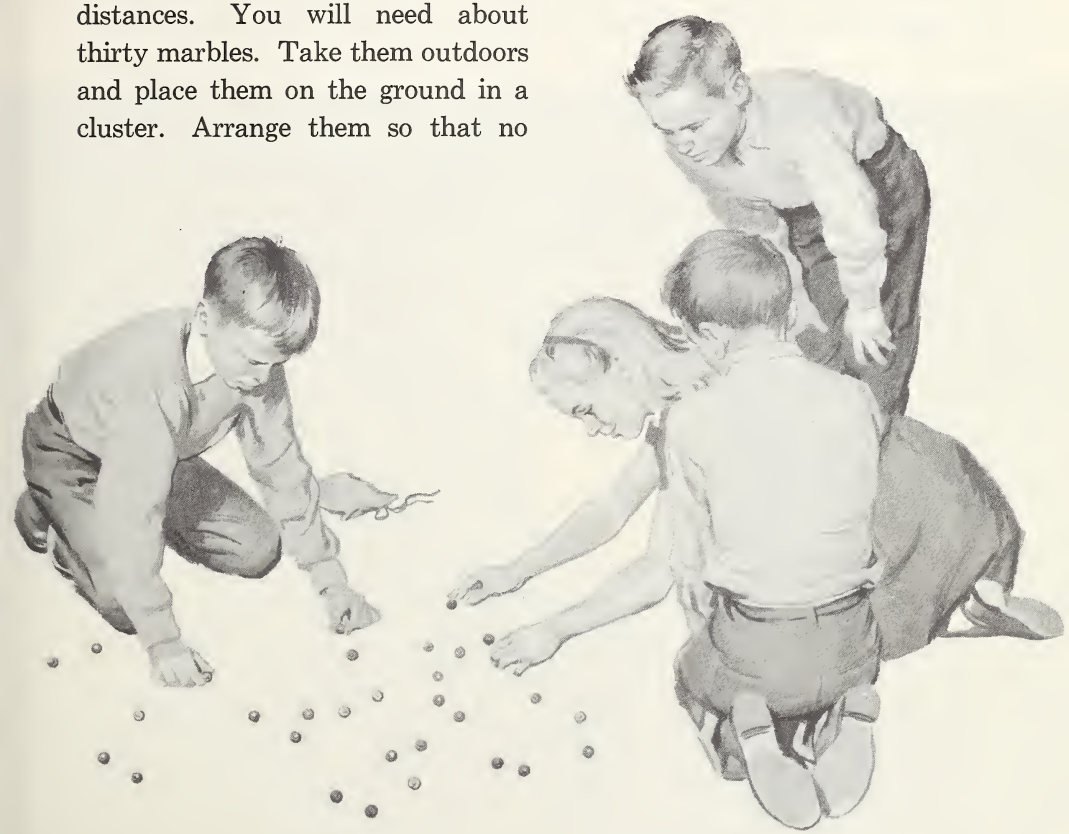
Without a telescope or glasses we cannot see many of the stars themselves in the Milky Way. This is because they are so very far away. We can see only the glow of light from all of them, arching across the sky. If we could follow this band of light, we would find that it appears to form a complete ring around the earth. The earth seems to be surrounded by this far-off band of billions of stars.

Stars Are Far Apart

As you look at the Milky Way, the stars appear to be very small and close together. Actually, even in what looks like a thick cloud of stars, each star is far away from its nearest neighbor. They seem to be packed closely together because they are all so very far away from you.

You might try an experiment. It will help you to understand why the stars seem to be close together, though they are separated by great distances. You will need about thirty marbles. Take them outdoors and place them on the ground in a cluster. Arrange them so that no marble is less than an inch from its nearest neighbor. You can see how this has been done in the picture.

Now stand so that you are looking toward the marbles. Slowly back away. As you back away, you will notice that the marbles seem to be moving closer together. Move about 50 feet from the marbles. Are you surprised to see how close together the marbles seem to be?

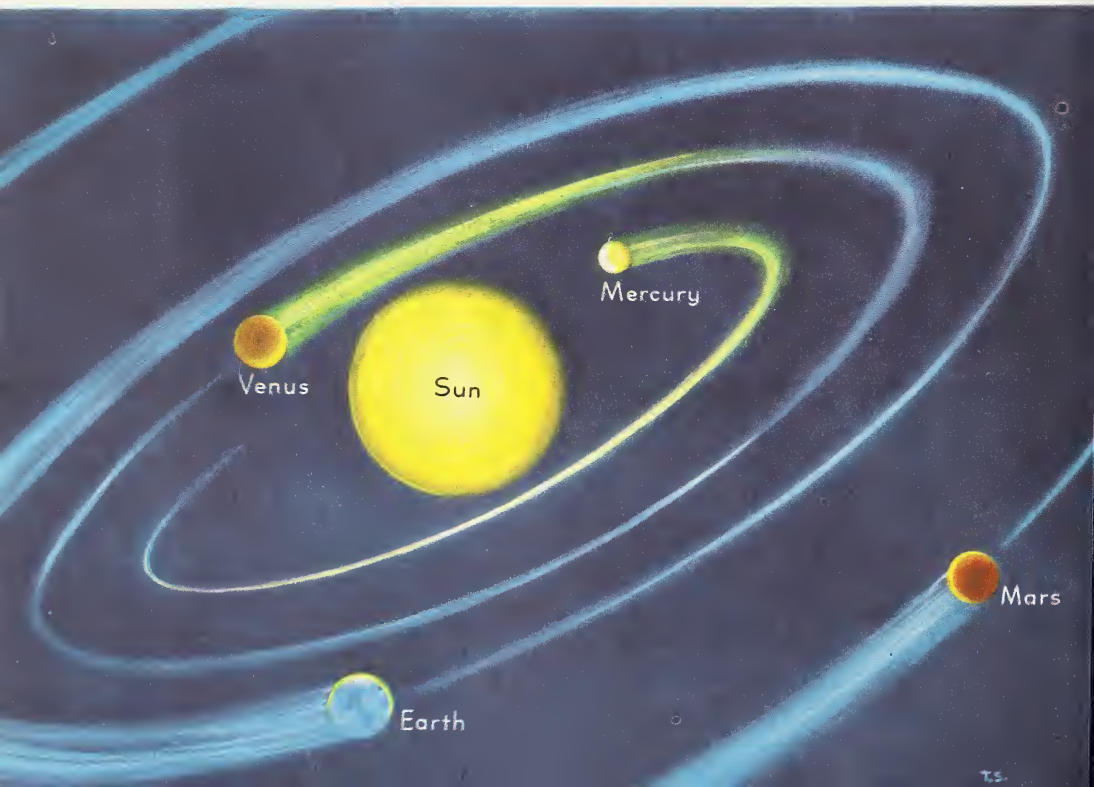


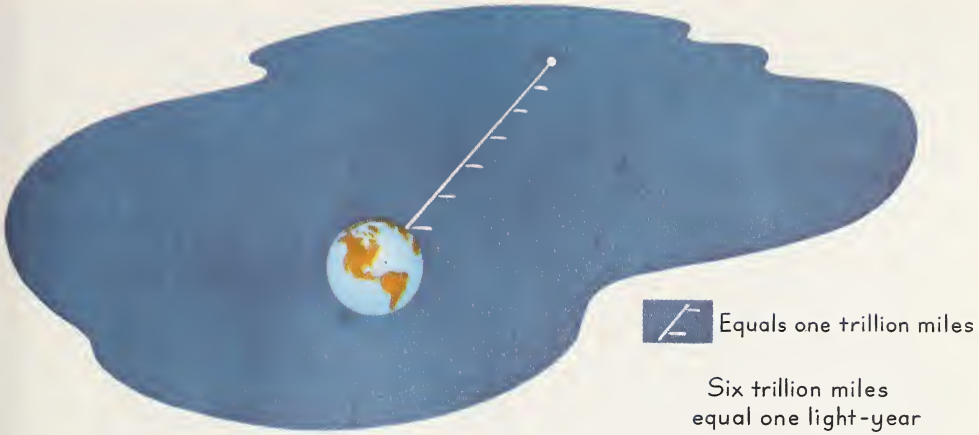
At about 100 feet you will probably not be able to distinguish the separate marbles in the cluster. But you will be able to see that they are of many different colors. Now if you use a pair of field glasses to look at the cluster, you will be able to see the individual marbles. Do you see that if you are far from a group of objects, the objects appear to be crowded together?

This is similar to what happens when you look at the Milky Way. You are so far away that the Milky Way appears to be only a band of light. When you use a telescope, you can see many individual stars which make up the group.

Distances in the Sky

Do you remember which star is closest to our earth? It is our own star, the sun. Three planets are sometimes nearer the earth than the sun is, but planets are not stars. Planets shine because they reflect the light from our sun. Stars are so hot that they glow with their own light. They are much like our sun. Some of them are bigger than our





sun, and some are smaller. We could say that all true stars are suns, or that suns are stars.

We can feel the warmth of the sun as it shines so brightly in our sky. Because of this we might think it is near the earth, but actually the sun is very far away. It is farther away than any place on earth. The sun is about 93 million (93,000,000) miles away from the earth. That is a rather long distance, isn't it?

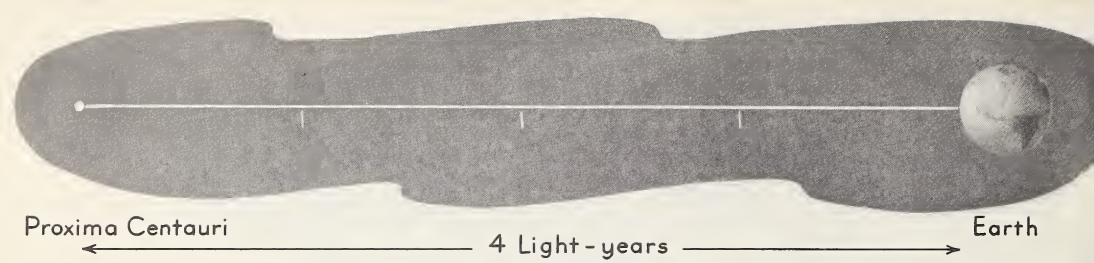
You might try to think of it in this way: Suppose you traveled toward the sun at a speed of about 700 miles an hour. Even if you traveled at this speed all day and all night, month after month, it would take you about 15 years to get to the sun. That is probably longer than the time that you have been alive.

Our sun is much closer to the earth than any of the other stars are. The next nearest star is more than 24 trillion (24,000,000,000,000) miles away from us. This star is called Proxima Centauri. If we traveled at 700 miles an hour, a trip to Proxima Centauri would take about 4 million years.

A Light-year

If the distances to the stars were measured in miles, the numbers would be very, very large. The numbers would also mean very little to us. After all, it is difficult for us to imagine 24 trillion of anything.

Astronomers use another way of measuring distances to the stars. Instead of saying that a star is so many miles away, they say that a star is so many light-years away.



A light-year is the distance that light energy travels in one year. Scientists have discovered that light travels about 186,000 miles a second. But that is only the distance traveled in one second. To find how far light travels in one year, you must first find how far light travels in one minute, in one hour, in one day, and then in one year. If you solve this problem, you will find that light travels about 6 trillion miles in a year.

Astronomers found that this figure was too large to work with easily. So instead of saying 6 trillion miles, they use the term *1 light-year*.

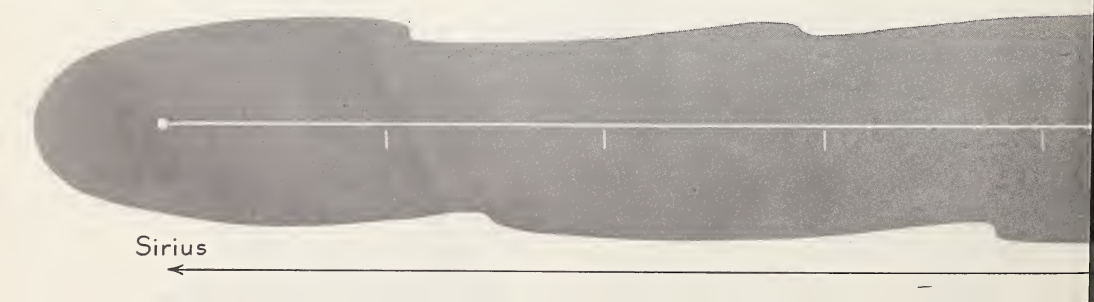
An astronomer might say that the distance to an object in the sky is 1 light-year. He means that to reach that object, one would have to travel about 6 trillion miles.

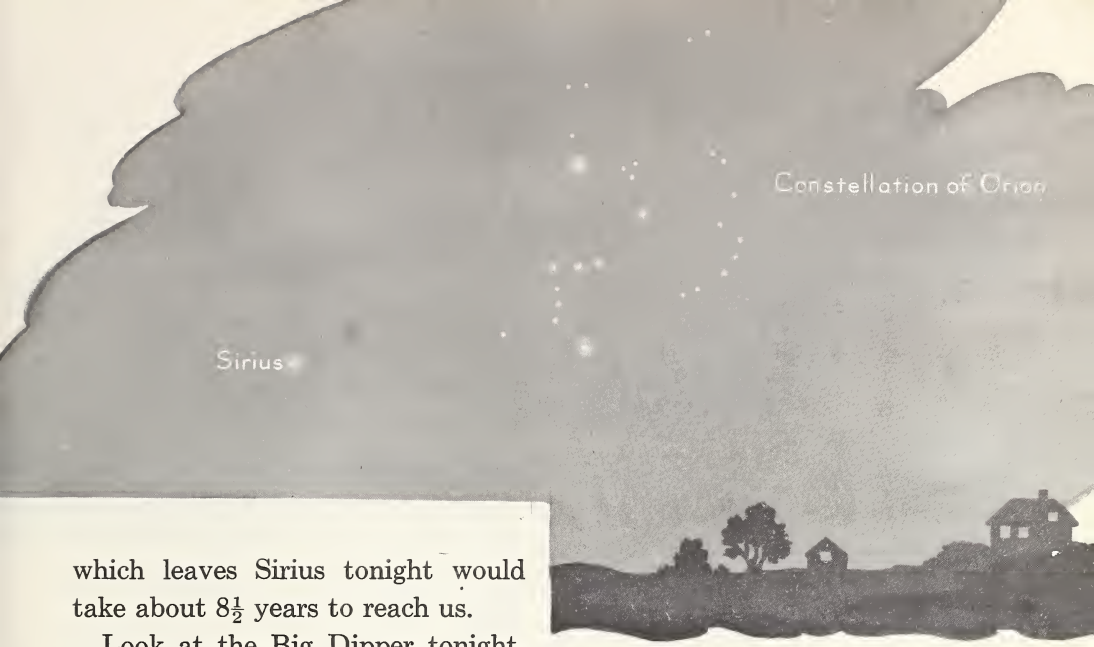
Using Light-years

The nearest nighttime star that people living north of the equator can see with the naked eye is Sirius. It is a very bright star in the sky during the winter and early spring. Sirius is about 50 trillion miles from the earth. It is about twice as far away as Proxima Centauri.

Instead of saying that Sirius is 50 trillion miles from the earth, astronomers say it is about $8\frac{1}{2}$ light-years away. If we should see Sirius in the sky tonight, we would know that the light by which we see it left the star about $8\frac{1}{2}$ years ago.

We might think of this distance in another way too. Let's suppose that Sirius should stop shining tonight. We would keep on seeing light from it for about $8\frac{1}{2}$ years more. This is because the light



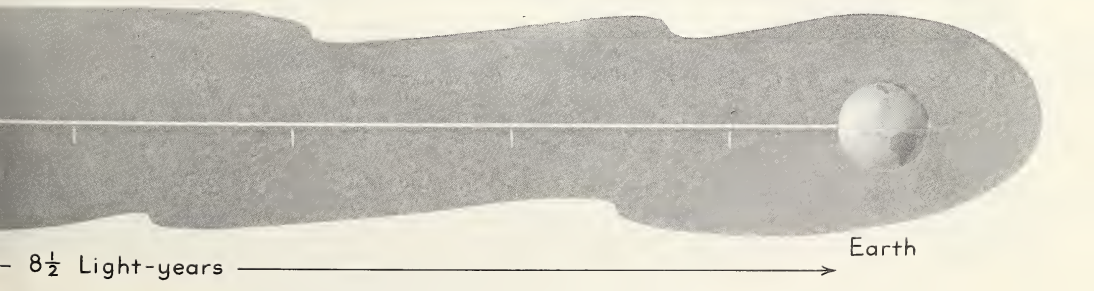


which leaves Sirius tonight would take about $8\frac{1}{2}$ years to reach us.

Look at the Big Dipper tonight. Some of the stars in the Big Dipper are about 100 light-years away. When you see them in the sky at night, the light you see left those stars about 100 years ago. That is longer than the lifetime of most people.

Stars around Us

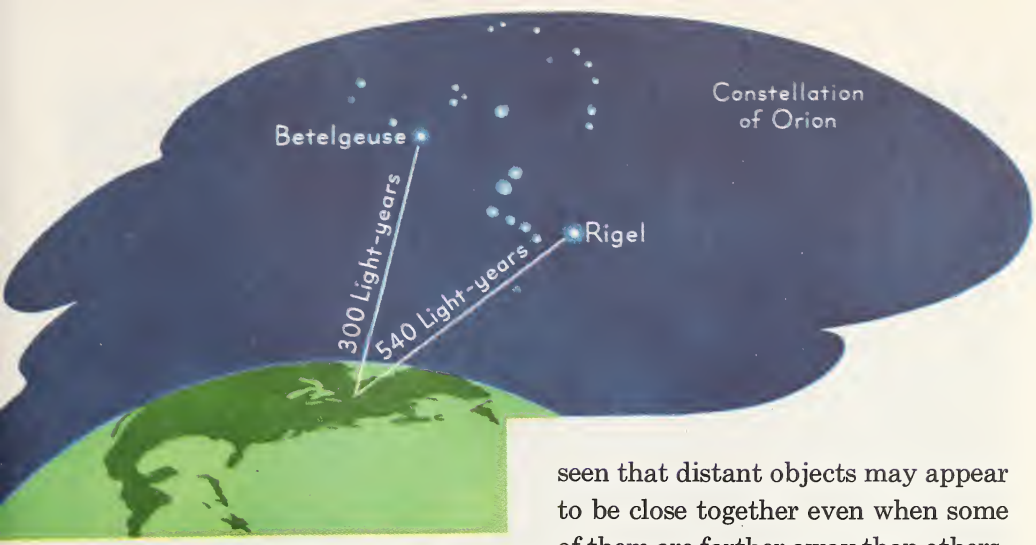
Notice the picture of the constellation Orion on this page. You might look for Orion in the sky in the winter or early spring. You probably know that a constellation consists of stars which seem to form a picture in the sky. Although the stars in each constellation appear to be a part of a single group, they are really not related to each other in any way. Some of the stars may even be millions of miles farther away from the earth than other stars in the same constellation.



Here is something you can do to help you to see how this is possible: With a ball of string lay out a straight line about 12 feet long on the ground. Arrange a dozen stones on the line about 1 foot apart. The stones should be about the size of a tennis ball. Then move six of the stones straight back from the line, as you see in the picture. You will notice that they have been moved different distances. You might move two of them about 6 inches, two about 1 foot, and two about 2 feet back. Now you will have one row of six stones in front, and you will have six other stones at different distances behind the first row.

Walk about 50 feet away from the stones and look at them. Move 100 feet away and look at them again. As you move farther away, it becomes more difficult to see that some of the stones are at different distances from you. If you move far enough away, the stones will actually appear to be in a straight line again.

This may help you to understand why the stars in each constellation seem to be part of a single group. In



the constellation Orion are two very bright stars. They are called Betelgeuse and Rigel. Because these stars seem to be near each other in the sky, we might think that they are about the same distance from the earth. Betelgeuse is about 300 light-years away. That is, it takes the light energy from Betelgeuse about 300 years to reach the earth. But Rigel is so far away that its light takes about 240 years longer than that to reach us. This means that Rigel is about 1440 trillion miles farther away from the earth than Betelgeuse is.

We say that these two stars are in the same constellation because they happen to be in the same direction from the earth. You have seen that distant objects may appear to be close together even when some of them are farther away than others. The stars which we see as a constellation are actually at quite different distances from us. So you see, the grouping called a constellation is an invention of man's imagination. It is a useful invention too because it helps us to pick out various stars easily.

When we think of such great distances, we can begin to realize how huge space is, and how small our earth. Yet to us the earth seems large.

The sun, our daytime star, is very much larger than the earth. It is important to us because it gives us light and heat energy, but our sun takes up only a small part of space. There are billions of other suns far beyond our solar system.

The Milky Way System of Stars

An astounding discovery was made by astronomers. They found that the stars in the sky do have a certain relationship to each other. Scientists tell us that all the stars that we can see with the naked eye are part of a single system of stars. This means that the Milky Way is not just a separate band of stars surrounding the earth. It is related to the rest of the stars in the sky, and it is related to our sun. Together our earth and the sun and the Milky Way and all the other stars we see make up one vast system. This system of stars is called the Milky Way system or the Galaxy or often simply the Milky Way.

Even more astounding was the discovery that there are other huge collections of stars out in space. These vast systems are also called galaxies. They are so far away that most of them cannot be seen without the aid of a telescope. The few that can be seen with the naked eye do not look like stars at all, but like small blurs of light.

The Shape of Our Galaxy

About 1785 William Herschel, one of the greatest astronomers, made a map of the stars. He counted the number of stars in different parts of the sky. Herschel believed that in this way he could find out how the stars in our system are arranged.

Of course it was impossible to count all the stars. So he counted the stars in portions of the sky. As he looked through his telescope, he found that there was a great difference in the number of stars in different parts of the sky. Looking toward the Milky Way, he counted many, many stars. When he looked in other directions, he counted a much smaller number.

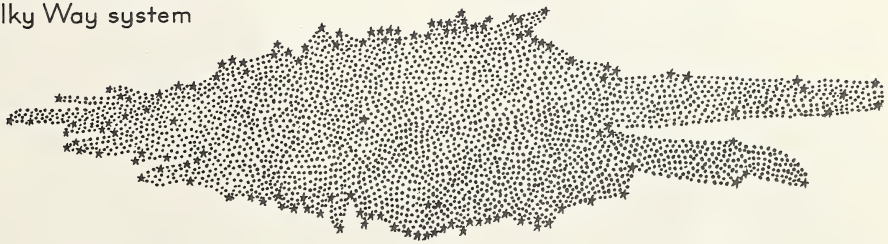
Herschel began to realize that there was an end to our system of stars, even though he could not see it. He also realized why the stars seem more numerous in some directions than others. He said that this is due to the shape of our system of stars and the earth's position within that system. The stars in our Galaxy seem to form a large wheel which is slightly thicker at the center, or hub.

In the picture below you can see Herschel's map of our Galaxy. He based his map on his star counts. Herschel said that the earth and our sun are part of this tremendous system of stars.

Our Sun and the Galaxy

To us on earth it seems that our sun is not a part of the vast group of stars we see in the sky at night. It seems this way because the other stars are so far away. The light from our sun is so bright that we are not able to see the other stars in the daytime. If we could travel far out in space away from the sun, we

Herschel's map of the Milky Way system



should see that our sun is really a part of the Milky Way system. As we looked back from outer space, we should see that the sun is surrounded by the other stars in our Galaxy.

Working with better telescopes and other tools, modern astronomers have located our earth and sun in this system more accurately than Herschel was able to do. They find that the sun and its family of planets are about halfway between the center of the Milky Way system and its rim. These astronomers have estimated that the diameter of our Galaxy is about 100,000 light-years. They say that at its center it has a thickness of about 10,000 light-years.

When we think of the earth's position in this great wheel of stars, it helps us to understand the appearance of that band of light we call the Milky Way. Here is something you can do to show this: You will need two glass pie plates and some brightly colored cellophane tape.

Stretch a piece of tape across the center of one of the pie plates from one side to the other. Now fasten a second piece of tape as you see in the picture below. It should cross the first piece about halfway between the center of the plate and its side. Tip the second pie plate upside down on top of the first and you will have a crude representation of the shape of our Galaxy. The point where the two pieces of tape cross represents the position of our sun and earth about halfway be-

tween the center and the rim of our Galaxy.

Now let's imagine that our pie-plate Galaxy is "filled" with stars. Of course the stars are far apart, but there are many of them. Can you see that there would be room for a great many stars between the earth and the rims of the pie plates? When we look toward the rims, we see so many stars that they seem crowded together. We call these stars the Milky Way. Looking from the earth toward the bottom of either plate is a much shorter distance. There are not so many stars between us and the space beyond our pie-plate Galaxy.

Another way to think of it is that it is as if we were halfway between the hub and the rim of a great starry wheel. When we look at the Milky Way, we are looking toward the rim of the wheel. There are so many, many stars between us and the rim that we cannot see them separately. If you think that you may be looking across the center of the wheel toward the rim on the far side, it helps you to realize why you see only a shining band of light instead of separate stars. However, when you look at the sky apart from the Milky Way, you are looking up out of the wheel. There are fewer stars, and so you can see the individual stars more clearly.

The whole Milky Way system, made of billions of suns, is moving through space. As it travels through

space, this tremendous system moves all together as one big unit.

The whole system is also turning like a huge wheel around its center. The sun and all the other stars are moving around the center of our Galaxy. Each one of these stars in this great system moves along its own path. At the outer edge of the wheel some stars are trailing along like the arms of a pinwheel. It takes a long time for the Galaxy to complete one turn. The sun takes about 200 million of our years to make one trip around the Galaxy. Some scientists think the Galaxy has made only about twelve turns since the earth was formed.

Other Galaxies

Astronomers think that there may be millions of other galaxies besides our own. These huge collections of stars are millions of light-years beyond our own Galaxy.

There is one galaxy which is visible to the naked eye from the northern part of our earth. If you look at the constellation Andromeda on a clear, moonless night, you may see a hazy spot of light near one of its stars. The stars in this constellation and in all the other constellations in the sky are part of our Milky Way system of stars. But when astronomers using telescopes studied this hazy spot of light in the constellation Andromeda, they found that it is not a star at all. It is not part of our Galaxy.

This tiny blur of light is actually a whole system of billions and billions of stars. It is over a million light-years away from our Galaxy.

The central portion of our Galaxy is hidden from us by huge clouds. But astronomers have made a study of the central portion of the galaxy in the constellation Andromeda. They think that our own Galaxy and the galaxy in Andromeda are similar in structure. In fact, they say that the Andromeda galaxy appears to us very much as the Milky Way system would appear to an observer out in space.

By the use of cameras and telescopes astronomers have been able to find many other galaxies beyond our own. Pictures of them, taken through telescopes, show that many are almost flat and round. This is much as we believe our Milky Way system to be. By studying these distant galaxies, we have been able to learn more about our own.

A Look at the Past

When you look at any of these distant galaxies, you are really looking across great spans of space. A million light-years is an enormous distance. You remember that light travels 6 trillion miles in one year. A million light-years would be a million times as far. Have you ever

stopped to think that when you look at such a distant object, you are also looking into the past?

The galaxy in the constellation Andromeda is the most distant object that you can see in the sky without the aid of a telescope. It is about 1,500,000 light-years away from the earth.

When you look at this galaxy, you are really looking back 1,500,000 years into the past. This is because the light that you see left the galaxy that many years ago.

In fact, you are not even looking at the galaxy where it is at the present time. You are looking at where it was 1,500,000 years ago. Remember that the light you see left the galaxy that long ago. The Andromeda galaxy has not been standing still. In those 1,500,000 years it has traveled billions of miles.

A portion of a cluster of galaxies

Clusters of Galaxies

Astronomers have found that every object in space seems to be part of a small group, which in turn belongs to a larger group. The sun and its family of planets are one such small group, which we call our solar system. We say that they form a group, or system, for several reasons. The sun is at the center of the group. The planets move around the sun.

The members of this group affect each other in many ways. If you have been swimming in the ocean, you have probably seen the tide "come in." The moon and the sun cause the tides that rise and fall in our oceans here on earth. This is one way in which our earth is affected by other members of the solar system.

All the parts of the system are in balance. Changes on the sun may bring about changes on the other members of the solar system. Finally, the sun is moving along in space, pulling the entire group of planets with it. The group we call the solar system is part of a much larger group, which we call the Galaxy.

But that is not all. Our Milky Way system belongs to a family of such galaxies. This family, or system, is sometimes called a cluster of galaxies. Such a system is, of course, so large that it is very difficult to

Galaxies vary in appearance

imagine. Galaxies millions of light-years apart may be members of the same cluster.

Some astronomers say that about nineteen galaxies make up the cluster to which the Milky Way system belongs. Several hundred other groups of galaxies have been found. Some of these contain hundreds or even thousands of galaxies each.

Finally, all the groups of galaxies thought of together make up the biggest group of all. We call this the universe.

We are not sure that this is the end of the story. Every time a larger telescope is made, scientists can see farther into space. With each new advance into space, galaxies have been found. Will this always be true? Shall we ever have a telescope large enough to show us an end to space?

Many scientists think it possible that we shall never see an end to space. Some galaxies may be so far away that their light will never reach us. If their light never reaches us, then we can never see them. No one really knows what kind of discoveries will be made about space in the future.

Our Expanding Universe

Many astronomers think that a long time ago the galaxies, including our own, were much closer together. It is as though there had been a huddle of galaxies. These men have set the time of the huddle at about 3 billion years ago. From that time to the present they tell us that the galaxies have been moving steadily apart.

There have been many explanations of how this might have been brought about. Many astronomers seem to think that about 3 billion years ago there was one big gaseous mass. In some way or other this gaseous mass exploded. From out of this explosive expansion the universe, as we know it, began. The turbulent masses of material gradually molded into the more regular forms we know as the stars and galaxies. This molding process is probably still taking place. It is thought that stars are still being molded from gas and dust formations.

According to this theory the material moved outward and away from the explosion. The galaxies started to spread and, to this very day, they are moving farther apart. Many astronomers believe that we are living in a universe which is growing bigger all the time.

LEARNING MORE ABOUT THE GALAXY

1. Luminous sky charts can be obtained from the National Equipment Service of the Girl Scouts. These charts will help you to locate the various stars in the summer and winter sky.

2. You might plan a trip to a planetarium or observatory if there is one near you.

3. If you enjoy taking pictures with a camera, you might try to photograph some of the stars. You can use any kind of camera. Place it on a box or other steady object and point it toward the stars. Open the shutter as wide as you can and leave the camera for several hours with the shutter opened. You can probably improve your results by experimenting. The streaks of light in your picture are called star trails. Can you explain them?

Light Energy All around Us

Light Energy and You

When did you get up today? Did you waken before sunrise or after? Perhaps you have never thought that most of us wait for sunlight before we get up in the morning. We plan a good part of our daily living according to when the sun rises and sets.

Some kind of light energy is with us almost all the time. Even when there is no sunlight shining on our part of the earth, we can usually push a switch and use electric lighting. In many towns there are street lamps, which supply light during the night. When there is not enough light, we can use flashlights, lanterns, candles, and many other things which provide light.

In fact, it is difficult to find a completely dark place even during the night. You might find a closet or some other such place in which it is quite dark. In a completely dark place you cannot see anything at all.

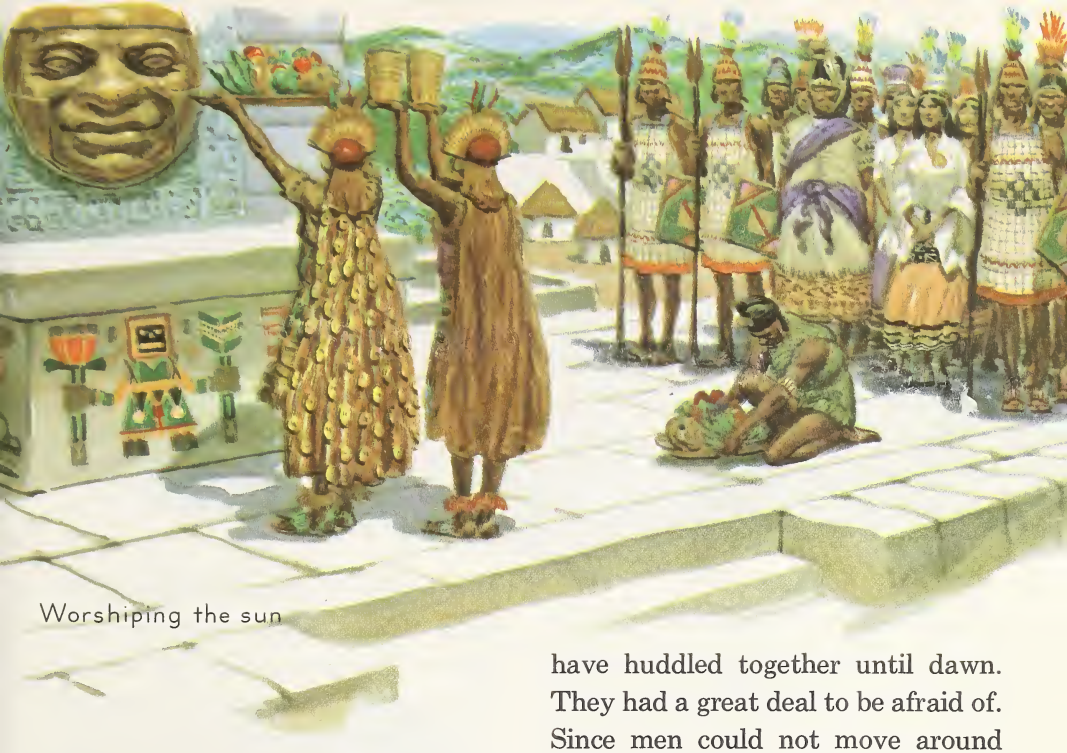
We Need Light Energy

It is through light energy that you are informed about many objects that are about you. Without light you would not be able to see anything. You would be cut off, in a sense, from the world around you. You would know of things only by touching, smelling, tasting, or hearing them. You would have a very different idea of what your world is like if there were no light energy to help you see.

If you have visited some of the large underground caverns near Carlsbad, New Mexico, you may have an idea of what it would be like in a completely dark world. No sunlight penetrates these dark, natural caverns. Electric lamps light the way as you descend into the dark depths.

On some of the trips through the caverns the guides tell you to sit down quietly. Then the lights are turned off. If everyone stays very still, you cannot be sure that anyone is near you. You are not able to see anything.

In our everyday living, light from the sun or from some other source is with us practically all the time. We have taken light for granted. Think how difficult and different your life might be if you did not have any light energy to use!



Worshiping the sun

Light and Early Man

Our earth was not always lighted at night the way it is now. There was a time when there were no street lamps anywhere on our earth. Once no one had a flashlight or lantern or even a burning torch to light his way at night or along a footpath in a dark wood. The only source of light was the sun.

Long ago it was only during the daylight hours that there was enough light for a person to see and move about easily. At night men must have huddled together until dawn. They had a great deal to be afraid of. Since men could not move around in the dark as well as the wild animals, they were at a disadvantage. They could not protect themselves as well at night as they could during daylight.

Sunlight must have been very welcome to these early people. The light from the sun made it possible for them to see the world around them. During the daylight hours men could be warned of danger before it was upon them.

Primitive people made many great discoveries. Probably one of the greatest discoveries was the use of

fire. At first fire may have come from wood which had been set burning by lightning. Long ago, people probably did not know how to start a fire themselves. So when a fire was set, it was very important for them to keep the fire burning.

Fire and Light

As man learned more about fire, he was able to use it for many purposes. He discovered that he could use fire to cook his food and to keep himself and his family warm. He also discovered that he could use the light from a fire.

At first people may have noticed that the light from a fire helped them to see objects around their camp at night. If they moved away from the light of the fire, it would be very dark, and they would not be able to see. Perhaps at some time someone picked up a stick which was burning at one end and carried it to light his way as he moved away from the fire at night.

When man learned that he could carry a burning torch to light his way, he had made a big step forward. Now he had a source of light which he could carry with him.

The discovery that a man could carry a torch to light his way brought new difficulties. When walking through a field or forest with a torch, someone may accidentally have started a fire. Such a fire

may have destroyed his home. Perhaps some members of his family lost their lives.

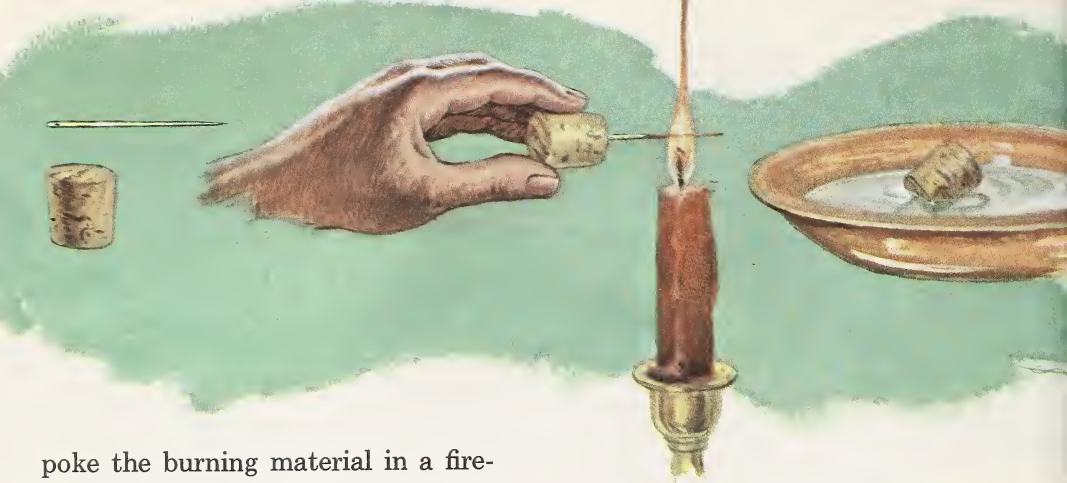
Each new discovery has probably always brought new problems. Certainly, as man learned to use the fire of a torch for light, he had many problems to solve. Some of these were solved by discovering other ways of using fire to produce light.

What Is Light?

For many centuries light was produced by the burning of some material such as oil, wax, or gas. To use these materials, such things as oil lamps, candles, and gas lamps were made. Before man was able to use other methods of lighting, he had to find out something about light itself and how it is produced.

Heating Produces Light

Perhaps in your home you have an open fireplace or a furnace in which wood or coal is burned. Many people use an iron poker to turn or



poke the burning material in a fireplace or a furnace. If an iron poker is left in the fire for some time, it becomes red and begins to glow. We say it is red hot.

You can heat something in your classroom till it is red hot. First, push one end of a small needle into a cork. Then by holding the cork, you can place the needle in a candle flame.

Notice the part of the needle which has been placed in the flame. When the needle has been heated for a short time, it will begin to give off a reddish glow. The reddish light will be seen easily as the needle receives more and more heat.

The needle must be heated to a certain temperature before it will begin to glow. If the needle is taken out of the flame, it stops glowing, but it is still too hot to handle. It is a good idea to cool such a hot needle by placing it in a pan of cold water.

High Temperatures and Light

As you may know, it used to be a common sight to see a blacksmith working with iron. First, he heated a piece of iron in a fire and then shaped the iron to make something from it. In order to shape the iron properly, he had to heat it to a high temperature.

You may think it would be difficult to know the temperature of a piece of iron as it is held in a fire. However, blacksmiths found an easy way to tell if the iron had been heated to the proper temperature.

Blacksmiths observed the color of iron as it was heated in their fires.

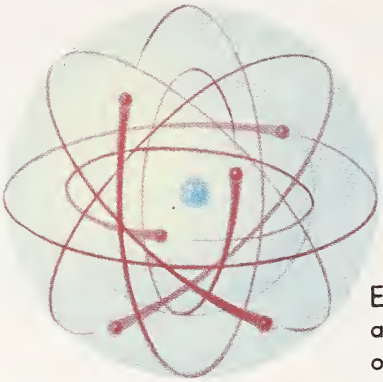
They noticed that after being in the fire for a while, iron began to give off a reddish glow. Then as they continued to heat the iron, they saw that it changed color still more. Its color changed from red to yellow. Before the iron gave off a yellowish light, it had to be heated to a higher temperature than that at which its light was red.

If a blacksmith had a very hot fire, he was able to heat the iron even more. He noticed that when he heated the hot, yellowish iron to a still higher temperature, it became white. It took a very hot fire to make the iron give off a white glow.

By observing the color of the iron, a blacksmith was able to tell how hot it was. He knew by the color of the light when the iron was heated to the proper temperature.

Men and women who studied this were puzzled about it for a long time. They asked themselves many questions. Why should a piece of iron give off light when it is heated? Why should the color of the light change as the iron becomes hotter?

These people developed many theories as answers to these questions. A theory is like a story which men invent to help explain what they see happen. Theories are usually not complete explanations.



Electrons spinning around the center of an atom of carbon

Light from Atoms

One explanation of why iron glows when heated is based on a theory about atoms. As you may remember, everything on the earth or in the sky is made of atoms. A small piece of iron is made of millions of atoms. A needle or a pencil is also made of millions of atoms. In fact, you are made of atoms, too.

Scientists tell us that the outer parts of atoms, called electrons, keep revolving very rapidly around the center of each atom. This is rather hard to imagine. Even with the most powerful microscope no man has ever been able to see what an atom or an electron looks like. Maybe no one ever will. But this theory helps to explain certain happenings which seem to be explained in no other way as yet.

This theory helps to explain why iron changes color as it is heated. As the electrons of the iron atoms receive more heat energy, they begin moving faster and faster. The more heat the electrons receive, the faster they move. The electrons now have more energy than they had before. It is believed that the electrons give off this energy as light.

When the electrons of the iron atoms have received only a certain amount of heat, they give off red light. If more heat energy is supplied to the electrons, they move faster and their light is yellowish. It takes much more heat energy for the electrons to give off white light. Electrons which glow with a white light are moving faster and have more energy than electrons which give off yellow light or red light.

Heating Metals

When a blacksmith heats a piece of iron, he is heating a piece of metal. Tin, zinc, and copper are also metals. You probably know of many more. You might make a list of as many metals as you can think of. We have started a list on this page. It would be a good idea to check to make sure that each thing on your list is really a metal.

List of metals	
Iron	
Tin	
Zinc	
Copper	

Man has discovered many different ways of heating metals. We have read how a metal can be heated by placing it in a flame. What would you suggest as another way of heating a metal?

The boy and girl in the picture on this page are heating a metal in another way. They are using electrical energy to heat a wire. If you wish to try their experiment, you will need a dry cell and a piece of insulated copper wire.

Connect an end of the wire to one post of the dry cell. Then hold the free end of wire against the other post of the dry cell. In a short time the wire will become hot. It will feel

warm to your hand, even though it is insulated. Electrical energy heats wire as it moves through it. It will heat a piece of wire so much that you cannot hold it. The wire will begin to cool as soon as you have disconnected it.

Some boys and girls tried an experiment to see if it was possible to make metal give off light without using fire to heat it. Instead of a flame they used electrical energy to provide heat. They experimented with a small, thin piece of iron wire. The picture on this page shows how they did their experiment. You might try this experiment, too.

You will need two pieces of insulated copper wire, one short, very thin piece of uninsulated iron wire, and a dry cell. First, fasten the wires together by twisting a piece of copper wire to each end of the iron wire. This will make one long strand of wire, consisting of the three pieces of wire fastened together.

Now connect one end of this strand to the dry cell. Hold the other end against the second post of the dry cell. In a short time all three pieces of wire will begin to get hot. But the iron wire will become much hotter than the copper wires.

This is partly because the iron wire is not insulated. It is also so thin that it is hard for electrical

energy to travel along it. The energy can travel along the thicker, copper wire more easily.

The iron wire becomes so hot that it will begin to glow. Electrical energy will make the iron wire give off light as it is heated.

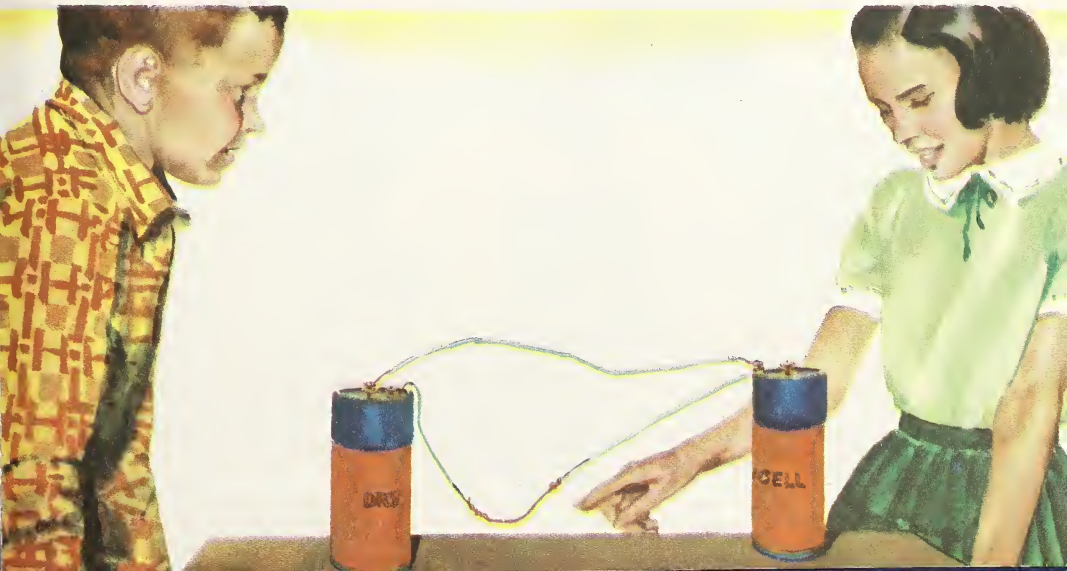
Heating Metals for Light

When a metal receives enough heat energy, some of the energy is changed into light. Each one of the metals on the list which you made will give off light when heated to a high temperature. This is not true of all things. Many things will burn when brought near a flame. However, it is possible to heat metals to very high temperatures without burning them. All metals begin to glow when they receive enough heat.

It is believed that the electrons of atoms of zinc, tin, copper, and other metals move in much the same way that electrons of iron atoms do. As their heat energy becomes greater, they too speed up and move faster and faster. Their additional energy is given off in the form of light.

You have done an experiment in which you heated a small piece of iron wire until it became so hot that it glowed. It would be possible to use a very thin, short piece of uninsulated copper wire in place of the iron wire. You might also want to use two dry cells, instead of one, for better results.

Electrical energy changes to heat energy in the wire. The atoms of the metal of which the wire is made become heated. When the electrons



of the atoms receive a certain amount of heat energy, they give off light. Electrical energy is really being changed to light energy. This is the same kind of thing which happens in the electric-light bulbs which you use in your home.

It is interesting to examine electric-light bulbs. There are bulbs of many different sizes and shapes. Many, such as the small bulbs used in flashlights, are made of clear glass. If you examine such a bulb, you will notice a very thin piece of wire. The thin piece of wire is made from a metal called tungsten.

Electrical energy is changed to heat energy in the tungsten wire of the light bulb. The heat energy is then changed to light energy. This happens when the atoms of tungsten are heated to a certain temperature.

Men who study about metals tell us that the color of the light is different for different metals. It has been discovered that each metal gives off its own particular colors when heated to very high temperatures. Scientists have found that this is very useful information. They can place a bit of metal in a flame and notice the color of the light it gives off. The color of the light will help them to know what the metal is.

Solar prominences

Light from the Sun

We have read how important sunlight was to early men. They depended on the sun as their only source of light. Even today our biggest source of light energy is the sun. Energy from the sun is just as necessary to us as it was to people of long ago. Of course we have come to realize its importance in ways not known by early men.

We know that the energy from the sun is necessary to green plants. The plants could not make food if they were not bathed in sunlight. Without plants we would lack food. In fact, we could not live at all without green plants.

Besides providing us with food, sunlight is important to us in many other ways. You might make a list of ways in which sunlight is valuable. It will help you to make your list if you discuss it with your friends.

How Is Sunlight Produced?

Think of the sun—that great generator of energy! What is it that produces the energy of the sun? How does the sun send out the great amounts of light and heat that reach our earth each day?

Men have probably always wondered what is happening inside the sun. We know that something must be going on which produces all that light. But what is it? It has been only a very short time since we began to understand much about the energy of the sun. About the year 1940 men who study the sun made some discoveries. These discoveries helped them understand how the sun's energy is produced.

These men found out that most of the sun, or about 90 per cent of it, is made of hydrogen gas. Atoms of hydrogen gas in the sun join together, and a new gas is formed. When four atoms of hydrogen gas combine, they form an atom of helium gas. Great amounts of energy are released when this happens.

All the atoms of the sun are heated to very high temperatures. The atoms are heated by the energy which is released when helium gas is made from hydrogen gas.

In the sun, in addition to the atoms of hydrogen and helium, there are atoms of other materials, such as iron, oxygen, carbon, and many others. As you know, the electrons

of atoms of metals and of some gases give off light energy when heated to high temperatures. The electrons of the heated atoms in the sun give off light energy in the same way.

Sunlight through Space

Light energy from the sun strikes our earth. It comes to us through space. The sunlight travels about 93 million miles from the sun to our earth.

Have you ever thought what it would be like out in space? Imagine that we went out in space, far beyond the earth. Let's even go out beyond our moon. What would it be like in outer space between our earth and the sun?

Most of this space is black. From outer space we would be able to see the sun and the other stars shining in the sky. But the space around us would not be light. This seems strange, doesn't it? If outer space is black, how does the light energy from the sun reach our earth?

No one has yet been far out in space to see what it is really like. However, from their studies scientists are able to explain how it must be. Light energy passes through space between our earth and the sun. We can see the light from the sun when it reaches our eyes, but it cannot be seen as it passes through space. There are many small par-

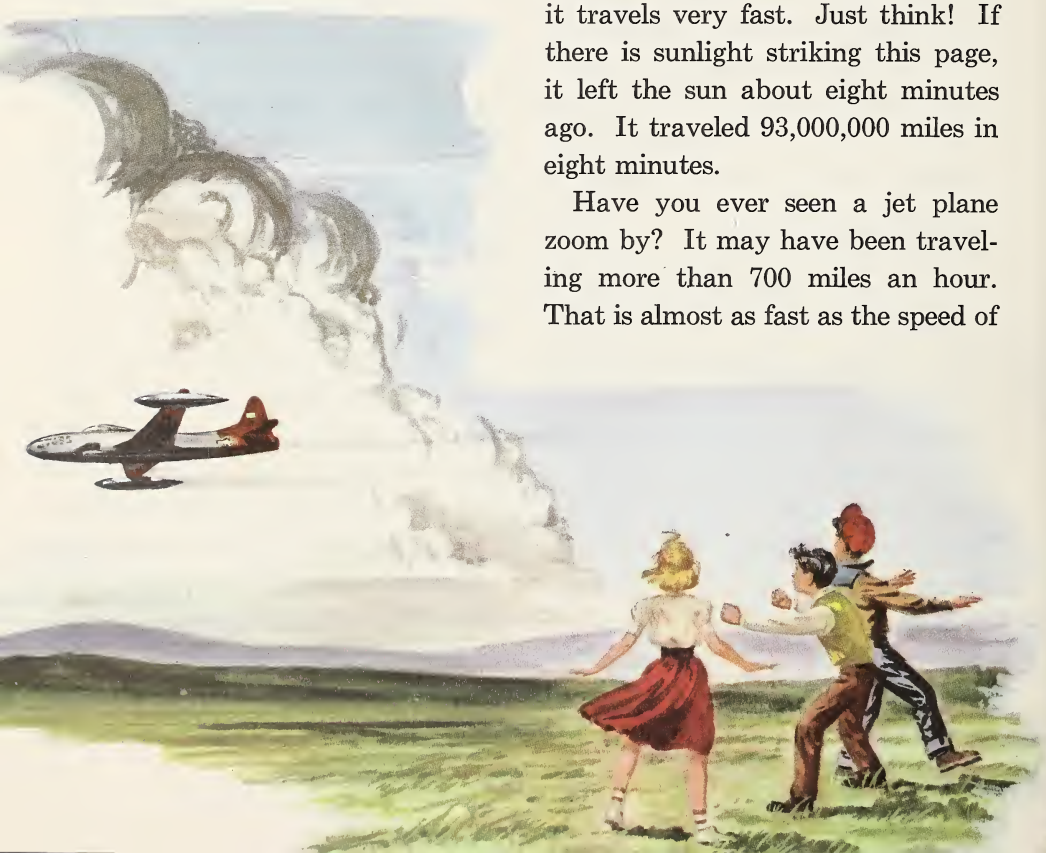
ticles in the earth's atmosphere. When the sun's energy reaches our atmosphere, it strikes these particles, and we see its light. There are few objects in the way of light energy as it travels from the sun to the earth. Most of outer space is thought to be empty. Since there are practically no particles for the energy to strike, outer space is black.

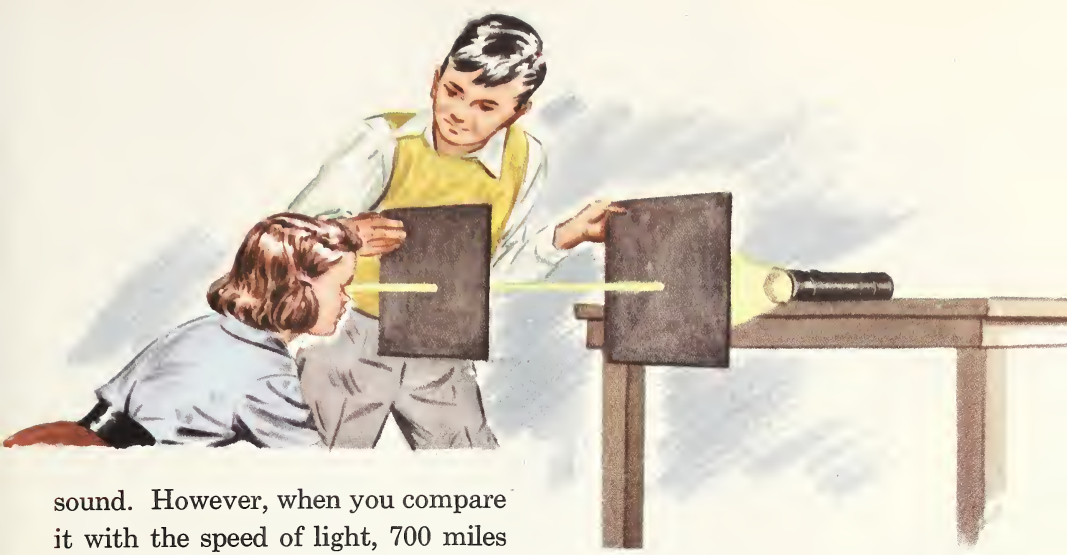
Experimenting with Light

We often hear people say that light strikes an object. They are right. Light energy strikes an object with a force that can be measured. Of course the force with which it strikes is very, very small, but scientists have measured the pressure of sunlight.

Part of the force with which light strikes an object is due to the speed of light. Light energy is moving and it travels very fast. Just think! If there is sunlight striking this page, it left the sun about eight minutes ago. It traveled 93,000,000 miles in eight minutes.

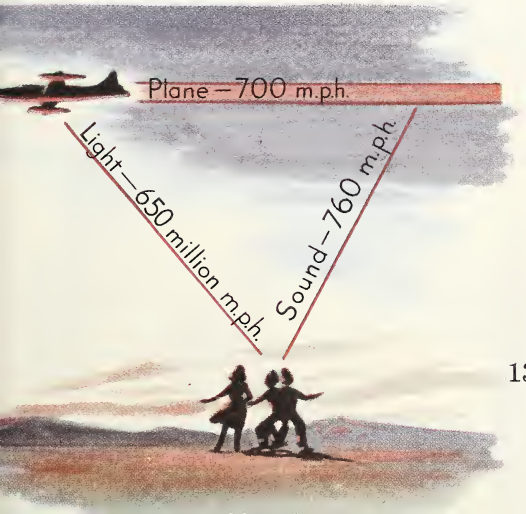
Have you ever seen a jet plane zoom by? It may have been traveling more than 700 miles an hour. That is almost as fast as the speed of





sound. However, when you compare it with the speed of light, 700 miles an hour is not very fast. Light travels 186,000 miles in one second. This is more than 650 million miles an hour.

You are able to see a jet plane, even though it is flying rapidly, because it moves much slower than the speed of light. The light can travel to your eyes from the plane faster than the plane can move.



The Movement of Light

We know that light energy travels in straight lines. The boy and girl in the picture above are doing an experiment which you might try. It may help you to see how light moves.

You will need a flashlight and two pieces of cardboard, each about 12 inches square. First, cut a small, round hole about the size of a dime in the center of each card.

Then place the flashlight on the table as you see in the picture. The boy in the picture is holding the cards for the girl. He is holding a card about 8 inches from one of her eyes. The other card is held between the first card and the flashlight.

First, the cards should be held so that the two holes and the light are in a straight line. Then by looking through the two holes, you can see the light.

Now move one of the cards about 2 inches to the right. Can you still see the light? You will not be able to see the beam of light, because the holes are no longer in line with the light. Light energy cannot bend around the cardboard.

Light Changes Direction

When light strikes a mirror, wall, or other object, some of the light usually changes its direction. But the light energy continues to travel in a straight line, even though it has changed direction.

Here is an experiment which will help you to understand how a beam of light changes direction: You will need a beam of sunlight which is coming through a window and striking the floor. Place a pocket mirror in this shaft of sunlight so that some of the sunlight strikes the mirror instead of the floor. Now there is a bright spot of light on the ceiling. Part of the sunlight is striking the ceiling instead of the floor.

A beam of light changes direction when it strikes the surface of a mirror. By moving the mirror in the sunlight, you can control the spot of light. You can make it shine on the ceiling or on the wall.

In going through air about us, light changes direction many times. You probably do not notice that light is changing direction, but it is happening all around you right now.

Light in a Hallway

We have read that light travels in straight lines. If it strikes an object in its path, the light may change direction.

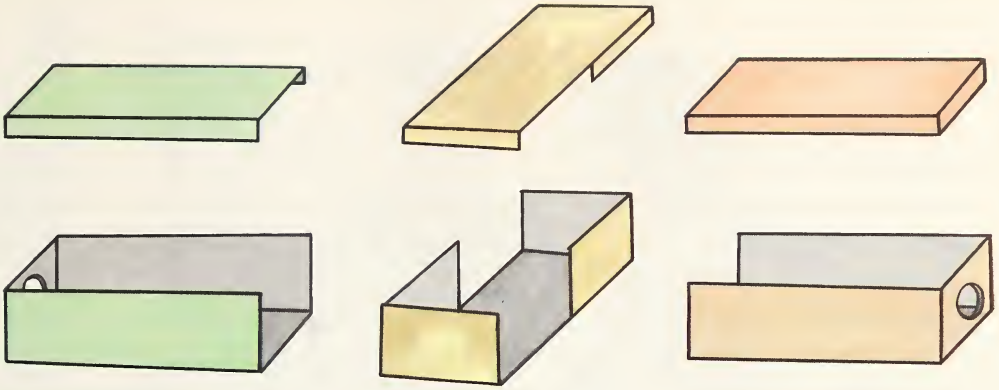
Let's see how this makes a difference in the position in which a light should be placed in the hallway you see pictured above. As you notice, there is only one light. You can see where it is placed now. Some boys and girls want to decide where it should be placed to light as much of the hallway as possible.

The boys and girls are experimenting to see how much light they can see at each position in the hallway. See where one girl is standing. How much light can she see when

she stands in that position? The light comes straight down the hallway. The girl can see a lot of light because the light travels in a straight line to where she is standing.

But what about the boy who is standing in the next position in the hallway? How much light does he see? The light travels in a straight line to where the girl is standing. When it strikes the wall back of the girl, it changes direction. Some of it strikes the other walls. And again the light changes direction. Now some of it is directed toward the boy. He is able to see some of the light.

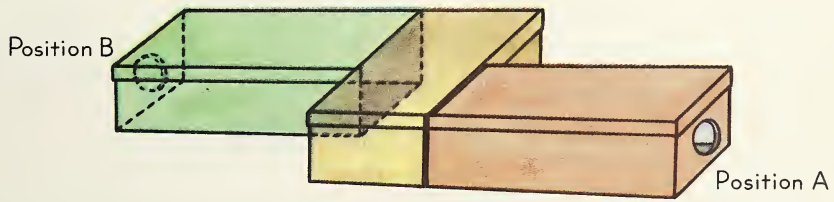
Do you think that the girl sitting at the far end of the hallway can see any light? You might try an ex-



periment to find out. You will need three shoe boxes and a flashlight. By cutting holes in the boxes and joining them together as you see in the pictures on this page, you can make a miniature hallway.

Place the flashlight in the position marked *A* in the picture below. Then look through the boxes from position *B*, which corresponds to the position in the hallway where the girl is seated. As you look down this part of the miniature hallway, how much light can you see?

You can use your arrangement of shoe boxes to test the amount of light that the other two children are able to see from their positions in the hallway. You remember that the boys and girls in the hallway started their experiment in order to find out where to place the light. They wanted as much of the hallway as possible to be lighted. Where do you think that the boys and girls finally decided that the light should be placed? Use your arrangement of shoe boxes to test your answer.



Let's Look at Colors

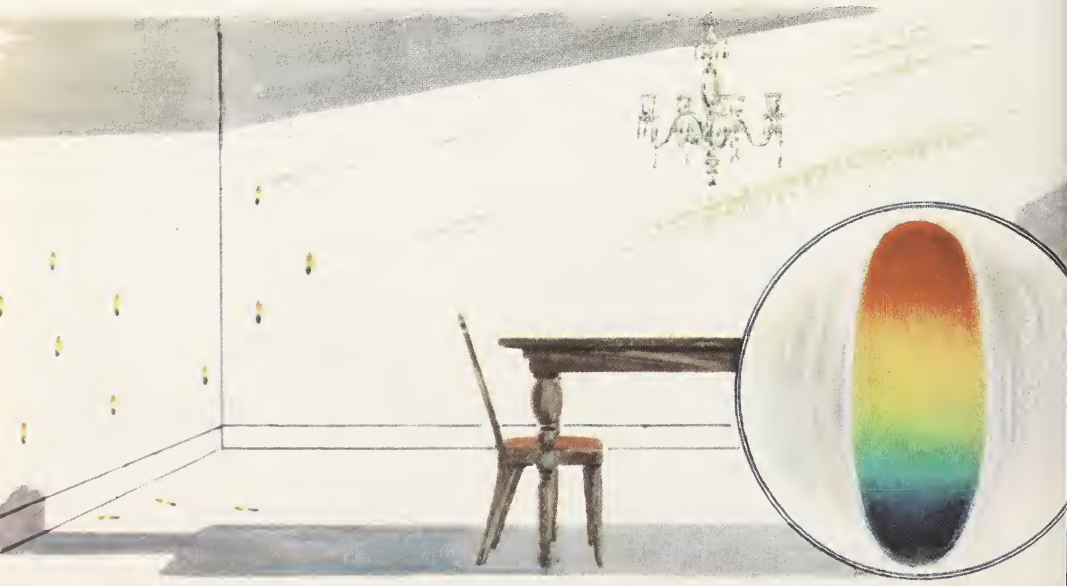
You already know that to see an object, you need light. When it is completely dark, you can see no objects at all nor any colors. When there is enough light, you can see colors of every sort.

Perhaps you have seen a rainbow in the sky. The spread of color is very beautiful. But look around! There's a great variety of color all about you. Probably there are many different shades of green, blue, and red. There must be shades of any color that you can name.

A Bundle of Light

Here is something you have probably seen happen many times: sunlight coming through a window may strike a piece of cut glass. In the picture below look at the cut-glass chandelier and the arrangement of colors which are striking the floor and the wall. You can see violet, blue, green, yellow, orange, and red. If the cut glass starts swinging in the sunlight, then the colors will also swing back and forth. Something happens to sunlight as it comes through a piece of cut glass.

You might say that a beam of sunlight is really a bundle of light. It is made up of many different colors of light. When sunlight strikes a piece of cut glass, the colors in the bundle of light change direction. As they go through the glass, they all change in the same direction,



but some change more than others. Violet changes direction more than the other colors do. Blue changes direction more than green. Green changes more than yellow does, and yellow more than orange. Red light changes direction less than any of the others. In this way the bundle of light is separated into its various colors.

The different parts of sunlight may be separated at other times also. We see rainbows in the sky because little drops of water change the direction of the light. Some parts of the light change direction more than other parts. This causes the various colors in sunlight to be spread out across the sky.

Where Do Colors Come From?

The color of objects depends upon the light that strikes them. The following experiment will help you to see this. You will need a green crayon and a large piece of bright-red cellophane.

First, color a large, green spot on a white piece of paper. Now place the paper in a beam of sunlight. Fold a piece of red cellophane and hold it so that the sunlight shines through several thicknesses of cellophane before striking the paper. Look at the spot which you have colored. It no longer looks green. It seems to be black.

When sunlight shines on red cellophane, only the red part of the sunlight shines through. The red light shines on the spot which you colored green. But there is none of the color green in the red light. So the spot that you colored no longer looks green, but black.

When an object looks red or blue or purple or any other color, we say that it reflects that particular color. You know that light can change direction. When light strikes a colored object, the object may send back only a small portion of the light. A red dish looks red because it sends back only the red part of the light which strikes it. If there were no red in the light, the dish would look black. It would send back hardly any light at all.

How do we see colors in our homes at night when there is no sunlight? The light which we use at night is given off by electric-light bulbs. If we see colors, they must be in the light from our lamps.

You might take a piece of cut glass and shine an electric light through it. You will find that you can see many colors. You will get better results if you use a flashlight and a piece of cut glass in a dark room.

There are many different colors in the bundle of light coming from an electric light. When you look at a blue dress by electric light, you can see the color blue because there is blue in the light coming from the electric-light bulb. The dress might look a different shade of blue in the sunlight. There is usually a different amount of blue in electric light than there is in sunlight.

You might try changing the color of light coming from a flashlight, much as you changed the color of sunlight, by experimenting with a piece of red cellophane. First, cover a flashlight with several thicknesses of red cellophane. Then darken the room and shine the red light on objects of various colors. Do you see how the colors change?

Your experiments with a piece of cut glass showed you that there are many different colors in the light from the sun. There are many different colors in the light made by electricity too.

Color adds to the beauty of the world. The colors of the trees, of the landscape, and of the clothes we wear make the world a much more enjoyable place. Colors are part of the light energy which reaches the earth each day from our sun.

LEARNING MORE ABOUT LIGHT

1. Place a pencil in a glass of water. Look at the pencil through the side of the glass. The pencil will appear to be broken at the place where the air and the water come together. What do you think is the reason for this?

2. When the sunlight strikes a spray of water from a lawn sprinkler, you may see a rainbow in the spray. How do you think the rainbow is formed? How would you explain a rainbow in the sky?

3. Place a piece of heavy colored paper behind a piece of window glass. You will be able to use the glass with the paper behind it as a mirror. Why is this so?

4. A man bought a blue suit. It was during the evening and the store was well lighted by electric lights. He liked the blue color of the suit. But when he looked at the suit in sunlight, he said it looked like a brighter shade of blue. How would you explain this?

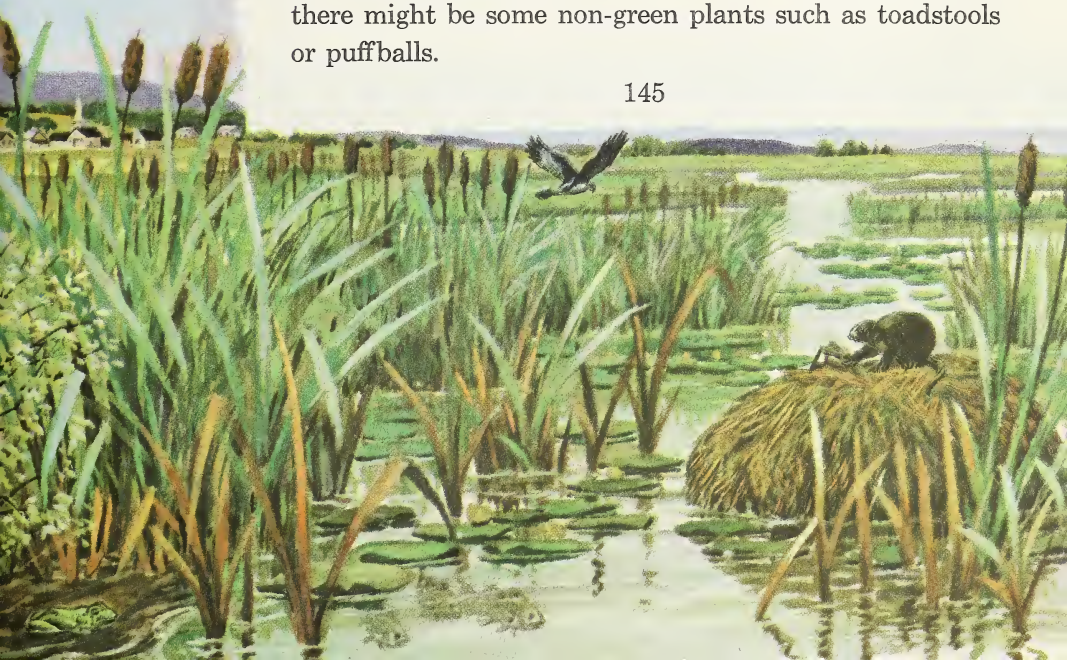
Plants and Animals Live in Communities

Communities All Around

If someone asked, "What is a community?"—what would you say? You would be right if you said, "My town is a community." Scientists studying plants and animals think of them as living in communities, too. But communities of plants and animals are quite different from your town or city.

Look at the places in the picture. In each part of this scene there are plants and animals. Wherever you look, you will almost always find plants and animals living together. The place where they live is called a community. If you looked in lakes, forests, grasslands, or streams, you would be sure to find communities of plants and animals. You would also find them in such desolate-looking spots as deserts, sandy beaches, and rocky hills.

A community usually has green plants. These are very important because they manufacture food and other things which the rest of the community needs. Many different animals can be found in the community, and there might be some non-green plants such as toadstools or puffballs.



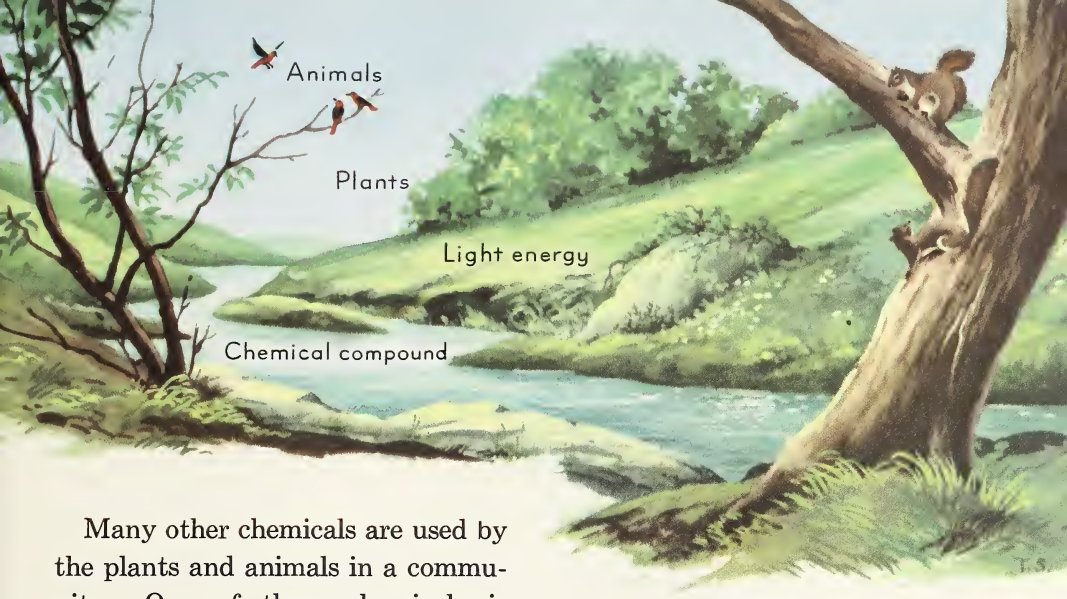
A group of plants and animals living together can usually find everything necessary to keep them alive right in their community. There is, however, a very delicate balance between them. If something happens to any part, the rest of the community is also affected.

Balance in the Community

As you know, animals depend either directly or indirectly upon green plants for food. In the arctic there are animals known as caribou. The caribou eat green plants such as grasses and dwarf willows. The caribou, in turn, are hunted as food by the wolves that also live in the arctic region. The wolves depend on the caribou and the caribou depend on green plants. So you see, the wolves depend indirectly upon green plants for food.

Green plants need energy from the sun to produce the plant material which animals use as food. So when we think of a community, we must think of the sun as well as of the plants and animals.

Plants also need certain other materials found in a community. These materials are called chemicals. Two of the most important of these chemicals are used by plants in food-making. You know these chemicals as water and carbon dioxide.



Many other chemicals are used by the plants and animals in a community. One of these chemicals is oxygen. Without a continual supply of oxygen no animal would be able to live.

Chemicals are a very important part of any community, but a community depends upon all its parts. Most communities consist of plants, animals, chemicals, and energy from the sun.

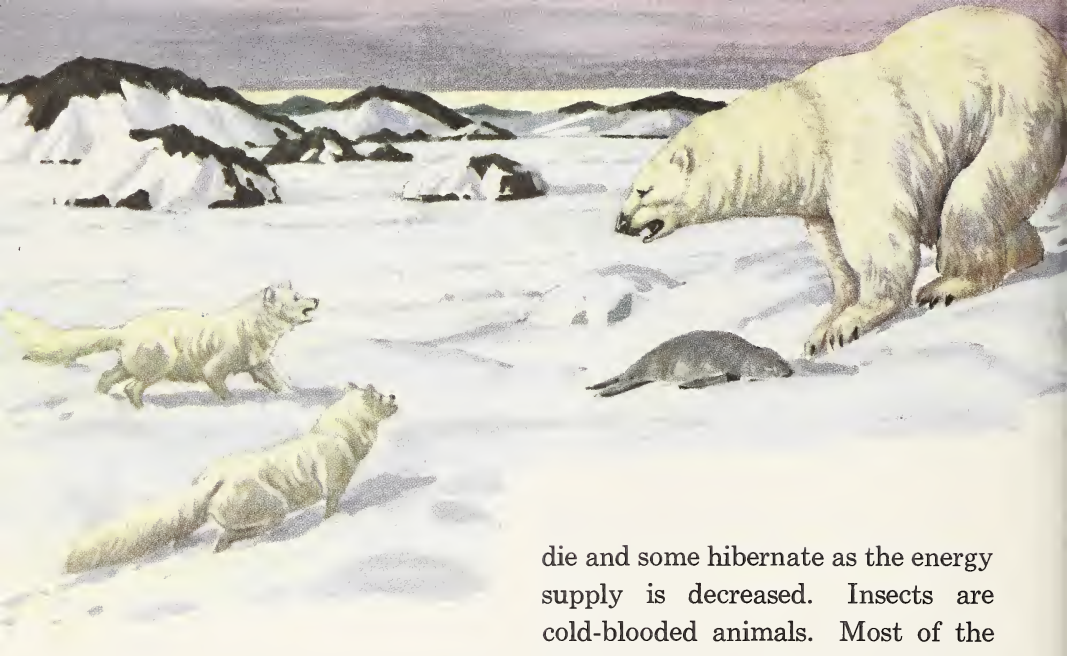
Energy and the Community

Energy from the sun becomes a real part of the community. It cannot be separated from the community without disturbing the community balance.

Most of the energy reaching our earth and all its many communities comes as light energy. Once it reaches the community, some of it is actually used as light energy. But most of it is changed into heat energy.

Only a small portion of the light absorbed by plants is used in food-making. It is changed by plants to chemical energy. The rest is changed into heat energy and is given off to the air, land, and water of the community.

Animals eat plants as food, and much of the chemical energy in the plants is then changed to heat energy. You might think of this process as somewhat like a "chain" of energy. This chain of energy extends from sun, to plant, to animal.



At each point in the chain most of the energy is changed into heat. In this way light becomes a part of the community. Without this energy there could be no life.

Changes in the energy supply of a community affect the whole community. On the island of Spitzbergen, off the coast of Norway, foxes are able to feed on birds, insects, and plants during summer. Summer is a time of plentiful energy supply in the community.

But as winter approaches, there is a decrease in the energy supply of the community, and most of the birds begin to leave. Some insects die and some hibernate as the energy supply is decreased. Insects are cold-blooded animals. Most of the plants go into a resting stage and do not produce food during the winter.

During the time of decreased energy supply the foxes must find ways of keeping themselves alive. They move out onto the frozen sea. On the ice they search for the dead bodies of seals, which are the remains of the unfinished meals of polar bears.

The ways in which plants and animals live are changed by changes in energy. The growth of plants is affected, and any changes in plant growth affect the food supply of animals. There is a constant change in the life of a community as its energy supply increases or decreases.

Temperature and the Community

You might think that the energy supply of a community depends only on the amount of energy which reaches it from the sun. But the energy supply also depends on the community as well.

Here is an experiment which will show that the community affects its own energy supply: You will need two boxes, a large pail, and three outdoor thermometers. Fill one box with sand. Place soil covered with grass in the other and fill the pail with water. Place a thermometer in each of the containers, just as you see in the picture. In each case the top of the thermometer bulb should be at least $\frac{1}{4}$ inch below the surface.

On a day when the temperature of the air is well above freezing, place the three containers outside. They should be placed so that they will be exposed to the sun during the day. It will help to have them beside each other so that they receive the same amount of sunlight.

Leave the containers overnight. As early as possible in the morning take a reading for each thermometer. Continue to record the temperature of the sand, soil covered with grass, and water every hour throughout the day.

When your record is complete, compare the temperatures. Does the temperature for each container stay the same as when you took your first

reading? Compare the differences in the way the three areas heated up during the day.

You probably will find that the sandy area heated up much faster than the grassy or the water area. Your record will probably also show that the sandy area was heated to a much higher temperature than either of the other two. Does the water heat up more slowly than the other two areas?

Again allow the containers to remain in the same position overnight. Repeat the experiment. Which container is at the lowest temperature in the morning? Which container goes through the greatest temperature change during the day? Which changes the least?

In all three cases there is a temperature change during the day. The sand, the soil with plants, and the water all heat up. Light energy becomes a part of each community by being changed to heat energy. The results of the experiment seem to show, however, that temperature changes less in water than on land. When soil has some kind of plant life, it does not heat up as fast as when it is barren.

This means that if the community is a sandy desert, we can expect great changes in temperature during the day. There will also be a great difference between day and night temperatures. On the other hand,

Communities affect their own energy supply

Broad-leaved forest

Prairie

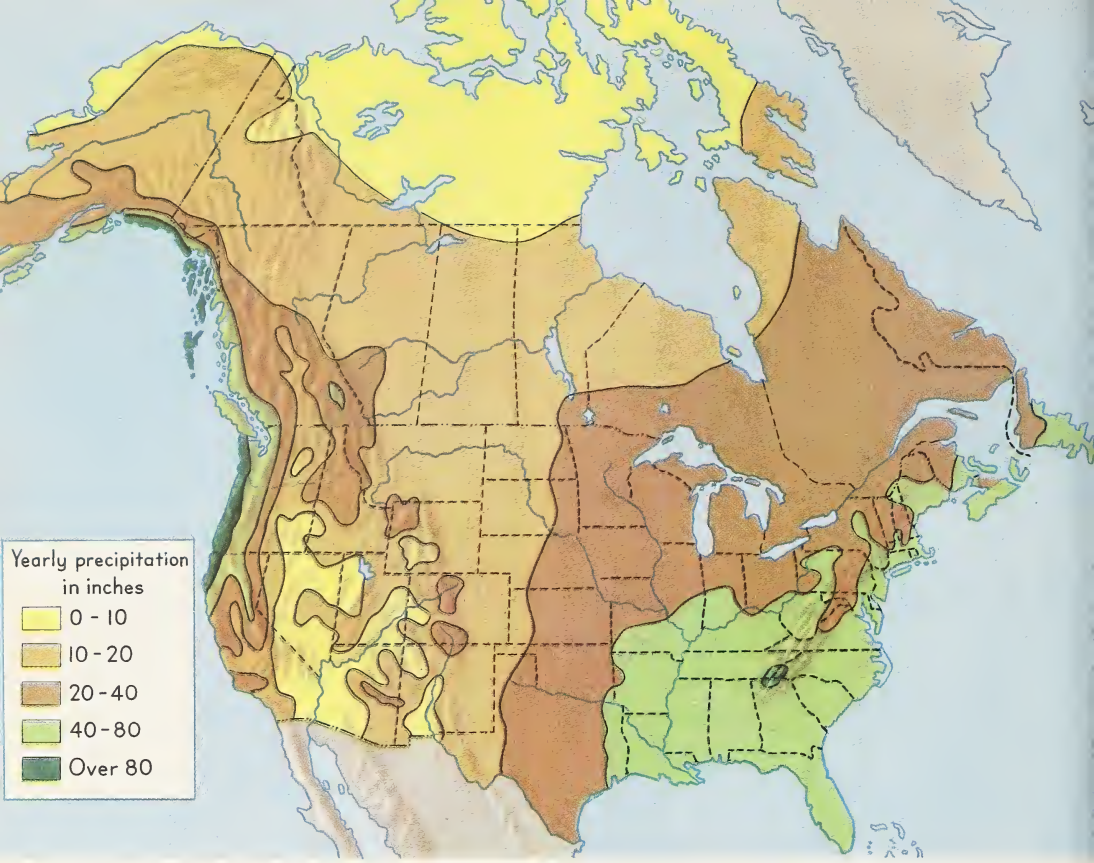
water communities will be slow to warm up and slow to cool off. The soil community with plant cover will not lose its heat as fast as bare soil.

Water and the Community

In some parts of the United States and Canada you will find forests as the plant cover for the land. The eastern part of North America is an ideal location for the growth of broad-leaved forests. When the rainfall is evenly distributed, there is always a good supply of water for the trees. Such forests can be found in the Appalachian Mountains in the eastern part of the United States. They can be found in Wisconsin, Minnesota and southeastern Canada as well.

In the prairie regions you will find tall, bluestem grass. The change in plant covering from trees to grass is brought about by a decrease in rainfall. The grass grows where there is not enough water for tree growth. In areas where the rainfall is even less there may be only enough water to allow short grasses to grow.

The kind of plant cover we find growing on soil depends partly on the amount of water available for the plants. The amount of water also affects the kinds of animals living in the community. Different kinds of plant communities attract different kinds of animals. Animals that live in the forests are not the same as those that live on the grasslands.



Water in the Air

The water that falls on the earth as rain, snow, sleet, or hail is called precipitation. The map on this page will help you understand how the amount of precipitation a region receives depends on its location. This in turn affects the communities in the region.

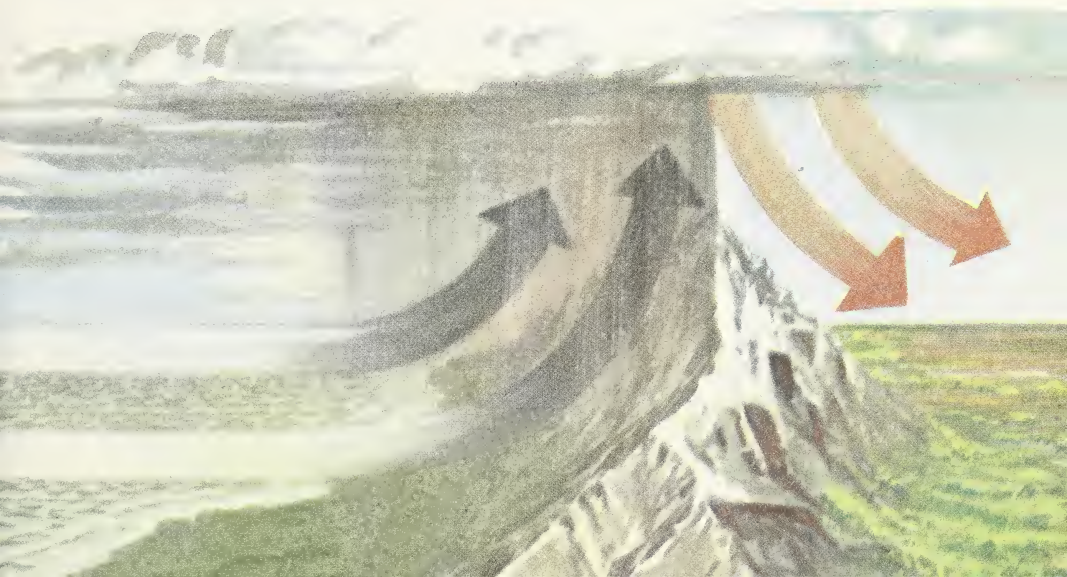
Winds blow off the Pacific Ocean toward the west coast. The winds pick up a great deal of moisture as they move across the ocean toward the land. They sweep across the land and are forced up and over the Sierra Nevada–Cascade Mountain Range. As the air is forced up, it begins to cool. The cooler it becomes, the less moisture it can hold. Most of the moisture in the air is dropped as rain or snow on the ocean side of the mountains.

You might try an experiment which may help you to understand why this happens. You will need two water glasses. Containers made of aluminum work very well, but any kind of drinking glass will do. Make sure the glasses are dry inside and out. Then pour hot water into one and fill the other with ice. As you fill the glasses, be very careful not to allow them to become wet on the outside.

Observe the outside of each glass. In a few minutes you will notice that the outside of one has become very wet, although the other is still dry.

The air in the room surrounds both glasses. One glass is hot and the other is cold. The air is warmed as it comes in contact with the hot glass, but it is cooled by the other.

The water forms on the outside of the glass which has the ice in it. As the air in the room is cooled, it gives up its moisture. This is because cool air can hold less moisture than warm air. It is for this same reason that the air on the ocean side of the mountains drops its water as rain or snow. As the air is forced up the mountains, it becomes cooled and cannot hold as much water as it did when it was warmer.



Very little rain falls in the region to the east of the mountains along the Pacific coast. When the air finally gets over the mountains, it is very dry. As it passes over the land just beyond the mountains, the air contains little moisture. If you look at the map on the opposite page, you will notice that this part of our country is a very dry region.

Communities of plants and animals that live well where there is an abundant supply of water are found on the ocean side of these mountains. On the dry side of the mountains the natural communities of plants and animals must be those that can get along with much less water. The two groups of communities are very different.

Rain and Other Regions

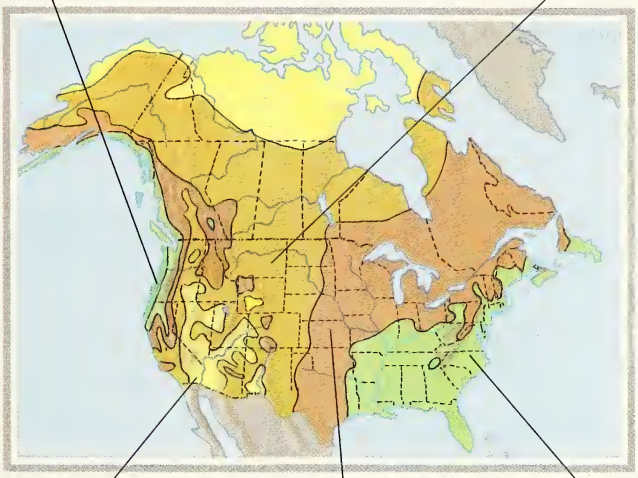
The Great Plains extend from Mexico into Canada. This region is one of high plains, which are from 3000 to more than 4000 feet above sea level. Much of the air that moves across this region comes from the dry land of Mexico. As it moves north over the Great Plains, it is warm and dry. It may rise and be cooled as it travels across the plains, but it contains so little water that not much rain falls. Most years are dry, and rain may not fall on more than 120 days in a year. It is often so dry that irrigation is needed to provide water for crops.

At times moist air does travel over the Great Plains, and when the air is cooled, much rain may fall. The rain that falls on one day may be more than a third of the rainfall of the whole year.

The natural plants of the Great Plains area are short grasses such as buffalo grass. This grass can stand the long periods during which there is no rainfall. Herds of buffalo were able to live on this short, tough grass. If proper care is taken, cattle can profitably graze on this land.

The prairie region lies in the heart of the continent. Warm, moist air from the Gulf of Mexico moves up over this area. When the air becomes cooled, it loses its moisture. Since rainfall is usually heaviest here in June, cereal crops grow well in this region. There is usually plenty of water for the plants when they need it for growth.

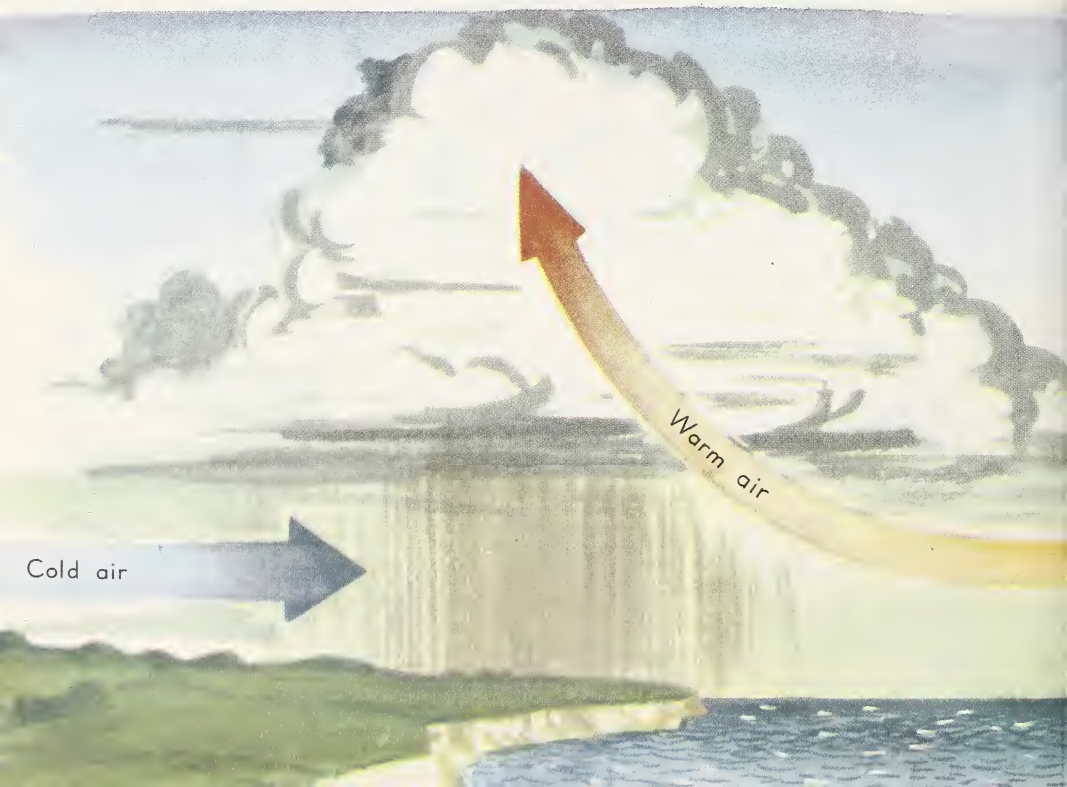
Look at the map. Can you suggest a reason why rain falls on the eastern part of the country? Warm air filled with moisture from the



Atlantic ocean often moves across the land. As it travels northwestward, it may meet dry, cold air which is moving into the eastern region from the north. The warm, moist air will be forced up over the cold air and will be cooled at the same time. As the air becomes cooled, the moisture it carries will fall as rain or snow.

Rainfall is plentiful in the eastern region. This rainfall allows for a great variety of plant and animal life.

The communities of plants and animals found in each region are very different from those found in other regions. Rainfall is one of the most important reasons for this difference. The rainfall in turn depends on the kind of air moving through the region. And we have seen that the movement of air depends on the location of the region. As you stop to think, you can also remember how temperature and energy affect the community. Yes, each of these things plays an important, necessary part in determining what the community of plants and animals will be like.



Studying a Community

You might plan to visit and study some small communities. Throughout the continent one of the most interesting and common communities is the kind that is found in a pond. A pond is a very small body of water and can be found in most regions.

In Shallow Water

The easiest part of a pond to study is the shallow-water area close to the shore. This part of a pond is usually shallow enough for light energy to reach to the bottom. You will probably find many plants with their tops above water and their roots in the soil at the bottom of the pond. In this way the plants are able to obtain carbon dioxide from the air above the pond. Water is taken up through their roots. As light energy falls on the plants, they are able to manufacture food.

Cattails, bulrushes, arrowheads, reeds, spike rushes, and pickerel weeds might be found in this part of a pond. You may also see some floating green plants such as duckweeds. These plants are not rooted and at times may cover the whole pond.

On many ponds there is a green scum floating on the water. This really consists of green plants called algae. If you examine the scum, you will see that it seems to be made of many tiny, green threads. Algae may often be found growing on rocks and sticks under the water.

In some parts of a pond you may see lily pads. They are to be found in fairly shallow water. The roots of the lilies are in the soil at the bottom of the pond. On the undersurface of a lily pad you may find water snails. Most snails feed directly on the plants and may be found crawling along on some of the underwater stems. You may find other animals attached to the stems and leaves of plants, too.

In Deeper Water

Farther out in a pond you may find many plants which are completely under water. Most of these underwater plants will have thin, finely divided leaves. Pondweed is the name given to some of the most

common of these plants. Other plants, such as coontail, water milfoils, waterweed, naiada, and wild celery, can also be found in some ponds. These plants are able to manufacture plant food because the water where they grow is still shallow enough for light energy to reach them.

Many animals may live in a pond as important members of the community. Some of the most common are frogs, toads, salamanders, turtles, and water snakes. Most water snakes are not harmful, but one should always be careful.

Tiny fish, called top minnows, are usually plentiful among the plants in most ponds. Catfish, bass, and pike may also be present. On the surface of a pond, animals such as whirligig beetles and water striders may be seen.

This is not the end of the story. Many other plants and animals make up a pond community. There is a great variety of life and activity in a pond.

Communities Change

At times the life in a pond may change greatly. Sometimes the changes may be brought about by things outside a pond community. Soil may be washed into the water from the surrounding land and fill a pond. Changes may also be brought about by great growth in the plant life of a pond. This would also start to fill a pond. The community would gradually change from a pond community to one which could live in a swampy area. In some regions of the country changes in a pond may be brought about by a long period of drought. A pond may just dry up.

A pond may gradually change from a water community to a land community. As these changes occur, new balances between plant and animal life in the community come about. This means that the kinds

Prairie chickens

of plants and the kinds of animals gradually change until there is a whole new community. You may know of some pond that has been gradually changed in this way during your lifetime.

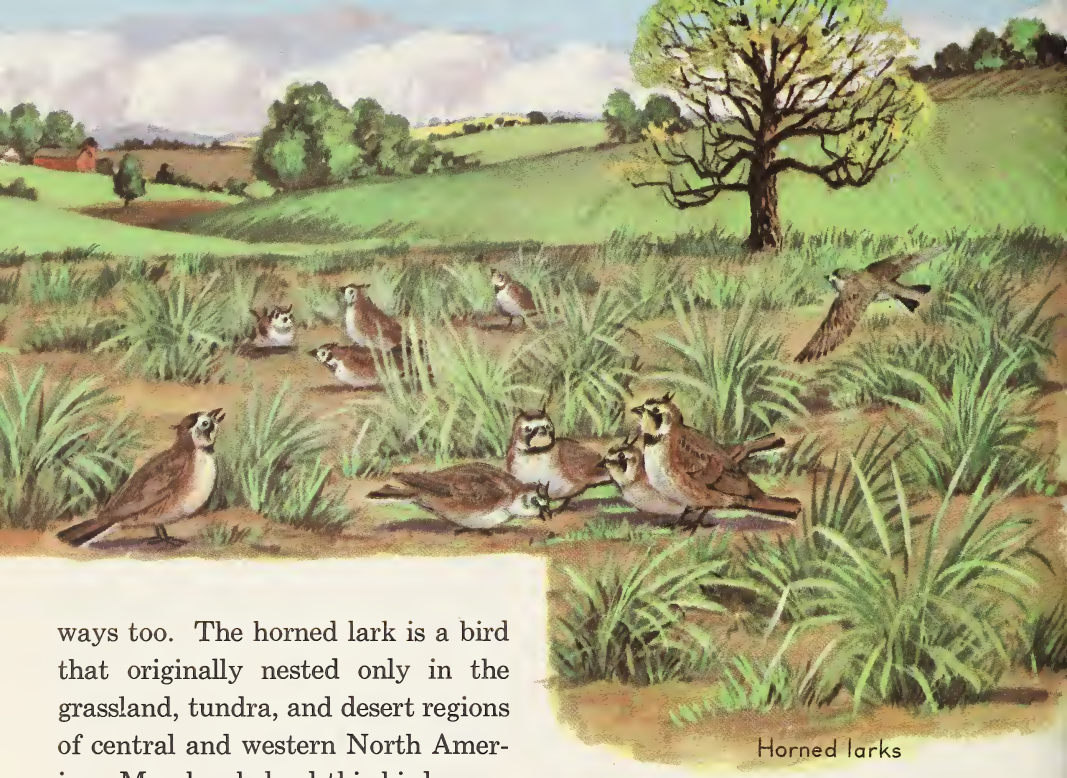
Man Affects Communities

In going about his business of living, man has greatly affected the natural communities of plants and animals which surround him. At times he has disturbed the balance so much that certain plants and animals could no longer continue to live as part of the community.

As man moved into the Middle West, he plowed up the grasslands and planted grain fields. This was a very necessary step forward on the part of man. But as he did this, he disturbed the balance that had existed.

The prairie region was originally covered with grass and wild flowers such as spiderworts, shooting stars, and violets. Some of the grass grew from 3 to 10 feet high. The large communities of prairie chickens which originally lived here were not able to survive when the grassland area was decreased. A grain-field community gradually replaced the grassland community. Over the years man has introduced pheasants as part of the grain-field community.

Man has created a favorable balance for certain animals in other



Horned larks

ways too. The horned lark is a bird that originally nested only in the grassland, tundra, and desert regions of central and western North America. Man has helped this bird.

When men from Europe first settled on the eastern shore of North America, a vast woodland covered the area. Gradually the woodland was cleared. Pastures, cultivated fields, and finally airports were established in place of the forests. Man had really set up grassland communities in the east. This established in the east a plant balance that was favorable to the horned lark. And so the lark spread eastward. It can now be found as far east as New York and Georgia.

Any change man makes in a community will have an effect on its appearance and make-up. When man makes changes in the community balance, he must be sure that they will be to his advantage. If not, he may regret them.

Man has put his understanding of community balance to work for him in many ways. He has come to realize that it is probably the only effective way of controlling the communities of plants and animals

which surround him. There is much to learn. Probably the most important thing man has learned is that he must be very careful. A change of any kind may have far-reaching effects.

LEARNING MORE

1. As the seasons change from summer to autumn to winter, there is a decrease in the amount of energy reaching a community. Describe some of the changes in communities of plants and animals as energy changes take place.

2. Mark out a 12-inch square on a section of soil. You might think of this as a little community. What kinds of plants do you find growing? Do you see any animals?

Dig down into the soil about 10 or 12 inches. If you are careful, you will find many things such as roots of plants, earthworms, and many other animals. Keep a record of the kinds and numbers of plants and animals that you find in this section of soil.

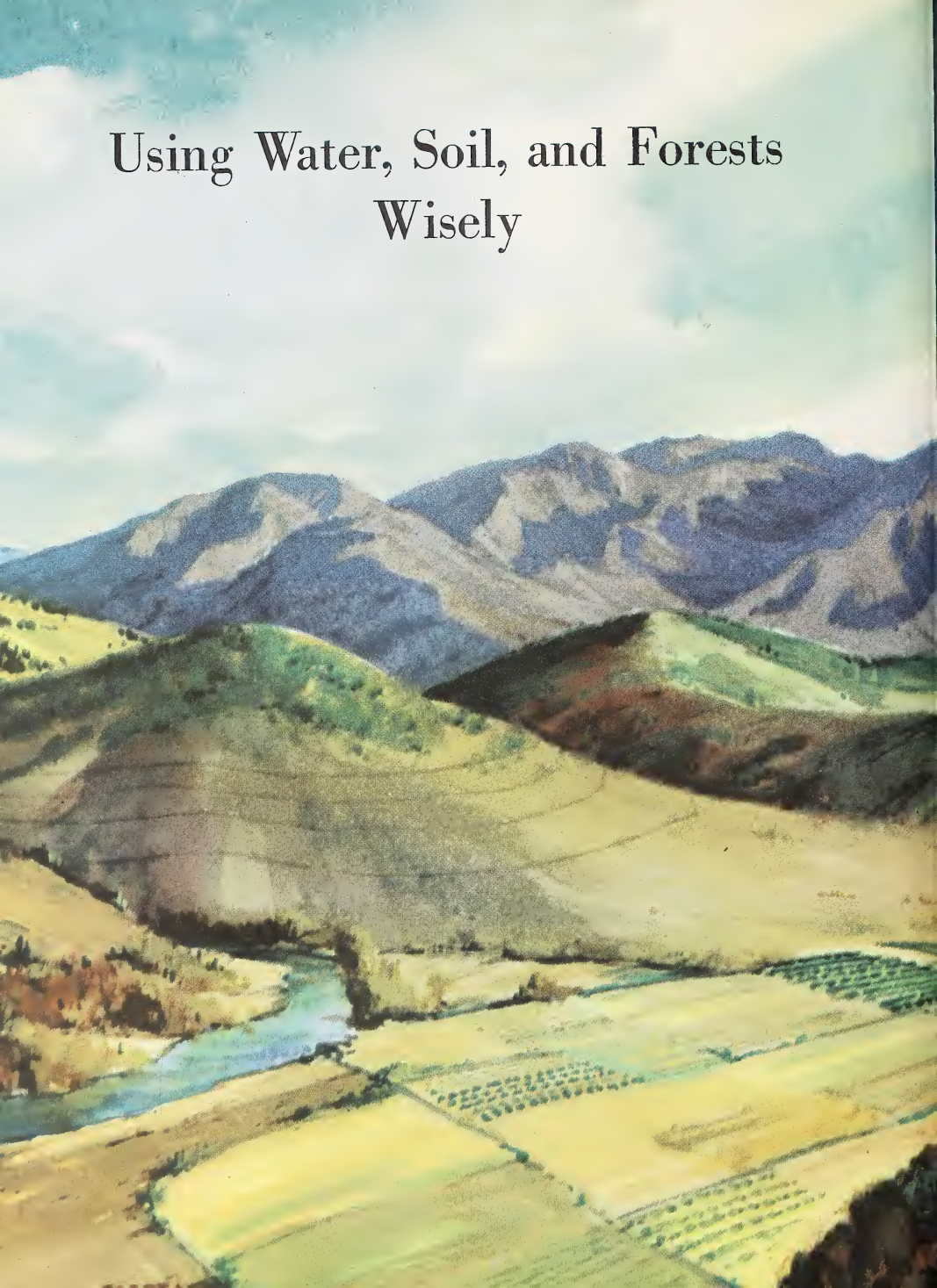
You might do the same for little sections of soil in different places. Compare your records when you have completed your observations. In what ways do the communities of plants and animals differ?

3. You might look in the newspaper and listen to the daily weather forecasts for news of the air movements over North America. How much rainfall is there in the different regions? Keep a record of the air movements and rainfall for a week, a month, or longer. What effect do you think these air movements and rainfall are having on communities of plants and animals?

4. Observe some of the animals in your community. What do they use for food? You will probably find that some of the animals do not eat plants for food, but they still depend on plants. List some of the ways these animals depend on plants.

5. Examine a fallen log which has begun to rot. You will probably find mosses, ferns, and mushrooms growing around and under the log. When you break off a piece of the log, you may even find an ant nest in it. What other plants and animals can you find in and around the log? Do you think the log forms a little community? What reason can you give for your answer?

Using Water, Soil, and Forests Wisely



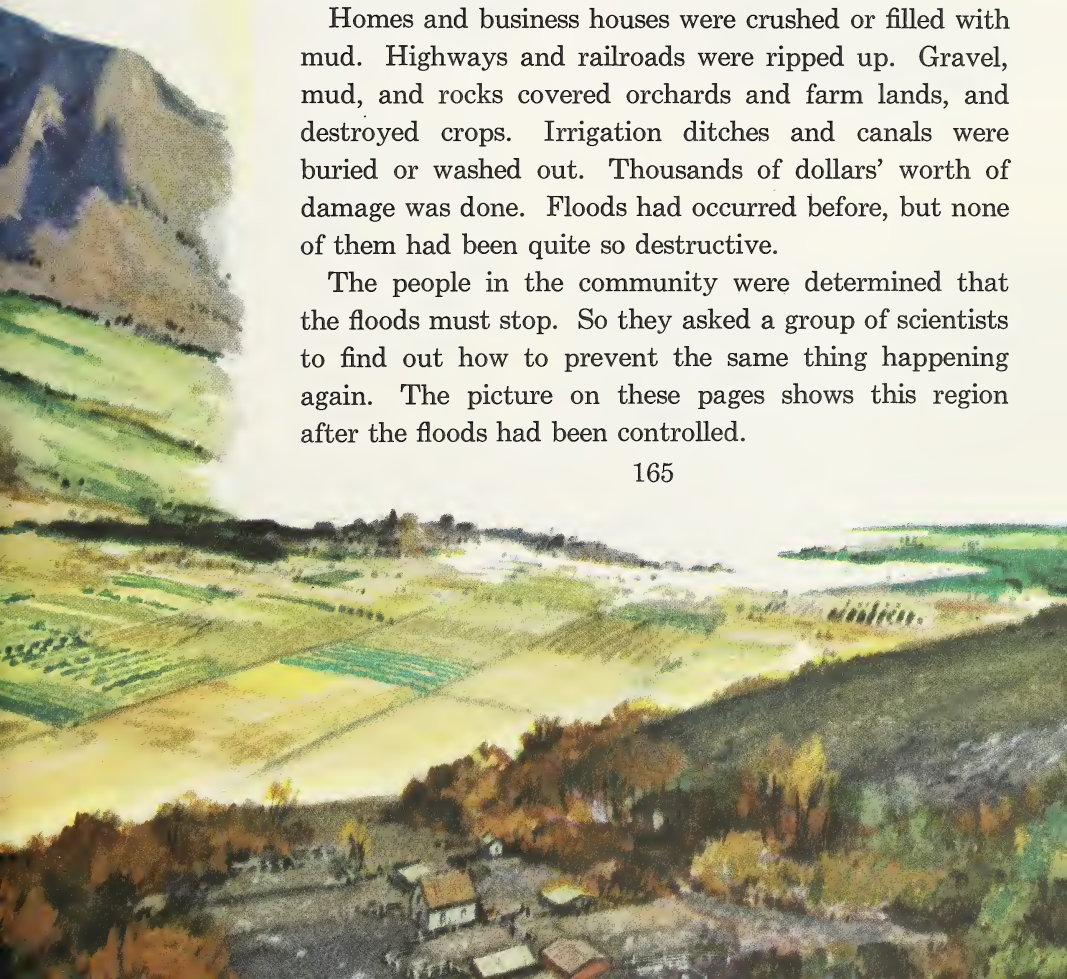
How Can Floods Be Prevented?

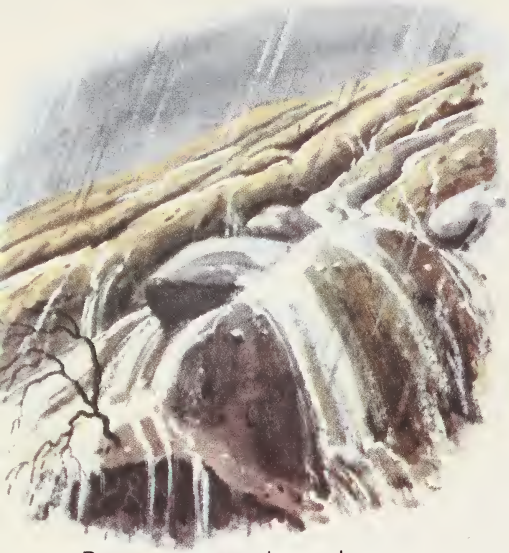
"Mud-rock Floods Wreck Town—Destroy Life and Property." Such was a headline some years ago in a newspaper of a city in the western part of the United States. The flooded town nestles at the foot of high mountains.

The storm started in the mountains on a hot, sultry day in mid-summer. Rain fell rapidly for several hours. As water rushed down the mountainsides, rocks and mud, gravel and boulders were carried with it.

Homes and business houses were crushed or filled with mud. Highways and railroads were ripped up. Gravel, mud, and rocks covered orchards and farm lands, and destroyed crops. Irrigation ditches and canals were buried or washed out. Thousands of dollars' worth of damage was done. Floods had occurred before, but none of them had been quite so destructive.

The people in the community were determined that the floods must stop. So they asked a group of scientists to find out how to prevent the same thing happening again. The picture on these pages shows this region after the floods had been controlled.





Rain on a steep, bare slope

Rain on a gentle slope

The Slope of the Land

Scientists studying these disastrous floods found that the flood waters came from the top of mountains behind the town. They said that the steep slope of the land had much to do with causing the floods.

We know that the slope of the land partly determines what happens to rain water. When rain falls on a steep, bare slope, much of the water will run off, and it will carry part of the soil with it.

Scientists know that the plants growing in an area also have a great deal to do with what happens to rain and melting snow.

Plants hold back falling water. They allow it to soak slowly into the soil. When there are no plants, the water runs off quickly.

Think how much water would run off slopes that have little grass or other plants growing on them. There would be nothing to hold it back. The swiftly moving water would rush down the slopes carrying soil with it, and it might cause floods on the land below. When this happens, water is harmful.

When there are plants covering the ground, some of the water sinks into the ground. The rest of it gradually flows into streams and lakes. Then we have a supply of water that is useful.

A Look at the Soil

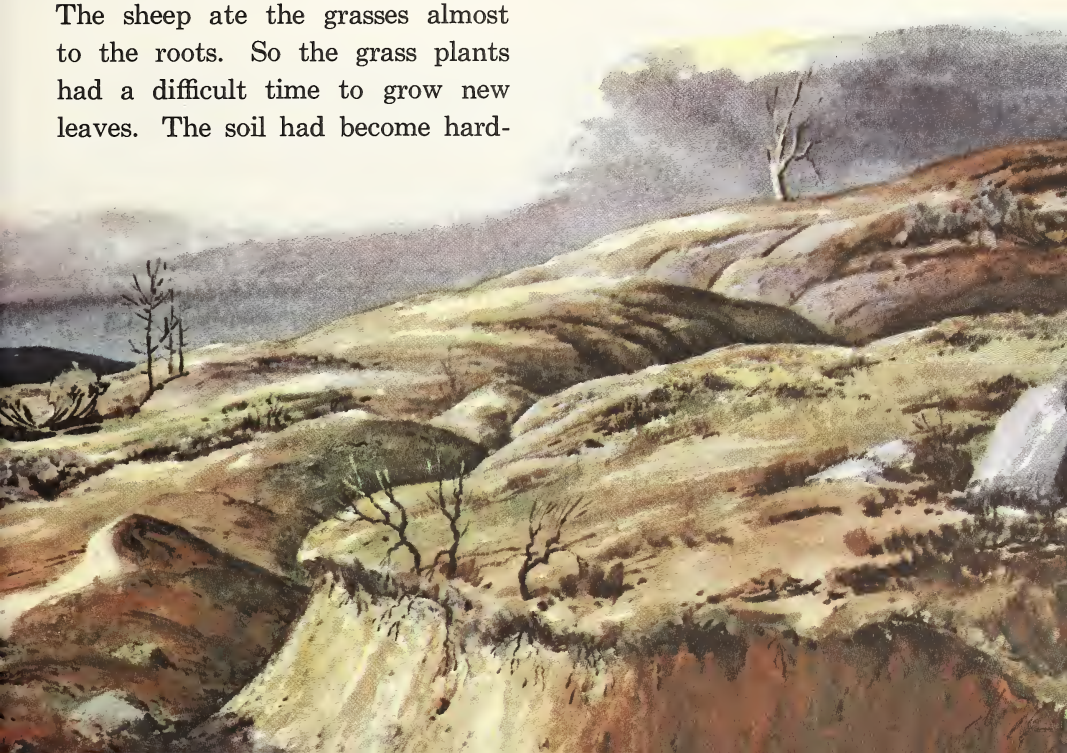
The soil on the mountaintops from which the floods had come had little plant life growing in it. The soil did not contain much moisture. In fact, its surface was hard.

There were patches of dead and dying plants which at one time had been growing in good soil. Some of the shrubs were blackened by fire. There was no grass. These were signs that the land on these mountains had not been used wisely. The soil had been abused.

What caused this to happen? The owners of the land had brought too many sheep to feed in this area. The sheep ate the grasses almost to the roots. So the grass plants had a difficult time to grow new leaves. The soil had become hardened by the trampling feet of so many animals.

Then the land owners had set fires to burn the thick brush that covered parts of the mountaintops. By doing this, they hoped to make room for new grass to grow. Instead, the fires destroyed most of the plants which covered the soil.

As a result of these abuses there was nothing to hold the rain as it fell. Water rushed down from the hard, bare slopes, carrying mud and rocks with it. It did not take a heavy rainfall to cause a flood in the valley below.



Contour trenches

The People Take Action

After the causes of the floods were known, something needed to be done. The people decided that no animals would be allowed to graze on the mountains, and no fires could be built. They made plans to change the slope of the land and to plant grasses on the bare spots.

To accomplish this, huge ditches were dug, curving across the slopes of the mountains. They were dug about 25 feet apart and they covered more than 1000 acres of the mountain slopes.

These ditches, dug by machines, are called contour trenches. Contour trenches catch and hold the water from rain and melting snow. The water cannot run down the mountainsides, causing floods. The trenches hold back the water and allow it to soak into the soil.

Between the trenches a mixture of different kinds of grass seed was planted. The moisture in the soil helped the plants to grow quickly. Soon the plants began to cover the mountain slopes.

Today the people who live in the town below these mountains do not have to worry that their crops and homes may be destroyed by mud-and-rock floods.

Look around Your Community

You have been reading the story of a community that learned what happens when land is overgrazed and plants are destroyed by fire. It is also a story of what can be done to restore land, so that it again produces plant life and prevents floods.

Think about your own community. Do you see steep hillsides covered with so few plants that rain or water from melting snow rushes down the slopes? Is soil being washed away? Perhaps there are areas where fires have destroyed trees and grass and other plants.

If these are some of the things you observe where you live, then the land is being abused. In some places water may have cut into the soil forming deep gullies. When rain falls or snow melts, the water rushes down gullies making them deeper and carrying away the soil.

One way to prevent water from rushing down a gully is to build a check dam. The picture below shows one kind of check dam. You can see the straw and brush held in place by fence wire stretched across the gully. This kind of check dam will catch and hold much of the soil in small gullies.

In addition to building check dams, it is possible to plant different kinds of grasses, shrubs, or trees in such gullies. The kinds of plants depend on which grow best in the area. However, it takes a long time to build up the soil. It is difficult to start any kinds of plants growing again when land has been abused and soil has washed away.

Perhaps bare slopes in your community have been reseeded to various kinds of grasses and other suitable plants. Sometimes bare slopes are planted with a kind of grass that has long, slender roots. These roots grow out in all directions. They hold the soil and prevent it from washing away. This is one way in which water and soil can be wisely used.

Using Water Wisely

It is fortunate for us that there is so much water on our earth, because we use a great amount of it. What are some of the ways in which we use water?

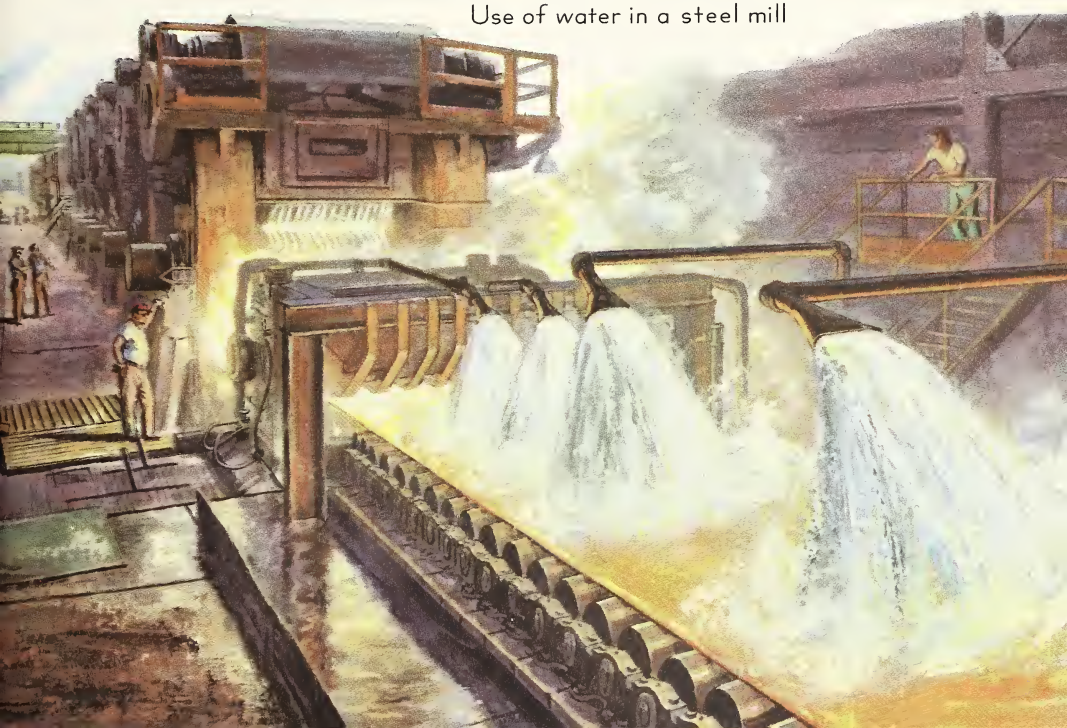
It takes a great deal of water to grow our food. To raise a stalk of corn requires about a barrel of water. It takes more than 1000 gallons of water to grow a bushel of corn. To raise an acre of corn requires thousands and thousands of gallons of water. The plants must get this water from the surrounding soil.

The animals that provide us with food need even more water than plants do. Animals drink a great amount of water each day. A milk cow may drink as much as 25 gallons a day. Animals also eat plants that use water. It takes almost 100 gallons of water to raise every pound of hay a cow eats.

In our factories we use a great deal of water. A paper mill uses millions of gallons of water every day to make the wood pulp from which paper is made. Cotton mills use many gallons of water in washing the cotton that is woven into cloth. A steel mill needs gallons and gallons of water each day. Many other kinds of factories also need water in making the things they produce. You might find out what some of the biggest uses of water are in your community.

Since we use such great amounts of water, we can understand why water is so very important to us. We each need about 100 gallons of water a day to keep our bodies clean and healthy. In fact, we know that we could not live without water. Where do we get all the water that we need?

Use of water in a steel mill



Where Water Comes From

We know that large oceans cover our earth. We also know that ocean water is salty, and in order to use it, we must remove the salt. At present it costs too much to remove salt from water by any method we know about. So our best sources of water are rain and snow.

When rain and snow fall on the earth, any one of these three things may happen:

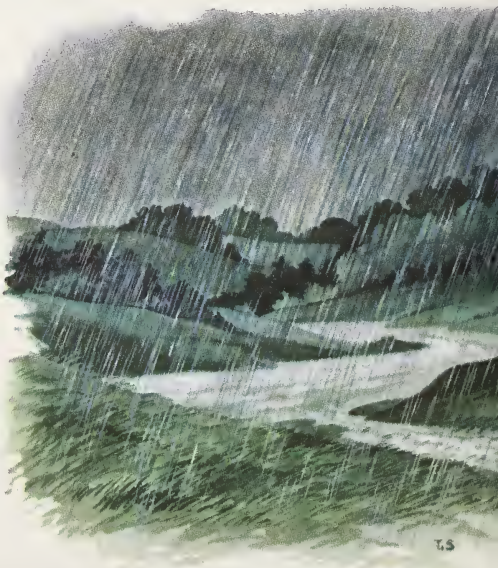
1. Some of the water from rain and melting snow may go back into the air. The water evaporates from the ground and plants.

2. Some water may run off the place where it falls and flow into lakes, rivers, and oceans.

3. Some water may sink into the ground. This is the water that fills our wells. Some of it flows beneath the ground into nearby lakes and reservoirs.

Just what happens to rain water depends on several things. If a light rain falls on a forest or on grassland, most of the water will soak into the soil. But if a heavy rain falls on this same land, some of the water will run off into nearby streams. It cannot soak into the soil fast enough. The heaviness of the rainfall is one thing that determines what happens to water.

You can see what happens when a heavy and light rain fall on a grassy spot. First, get permission to use



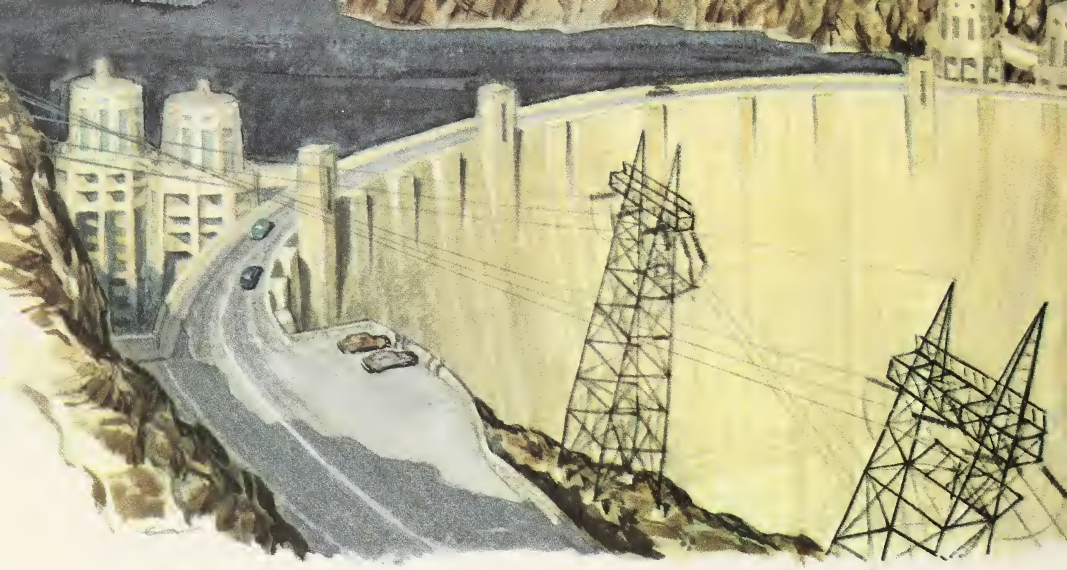
two grassy spots on the school grounds or in your neighborhood. You will also need a watering pot and a pail of water.

With the watering pot sprinkle water on one grassy spot. Notice that drops of water collect on and around the grass blades. The water gradually soaks into the ground. This is what happens when a light rain falls on a forest or on grassland.

Now pour the pail of water on the second grassy spot. Observe that some of the water soaks into the soil, but much of it runs off in all directions. You may even see some of the soil washed away around the blades of grass. From this demonstration you can understand what a heavy rain might do.

Not all parts of the country receive the same amount of moisture each year. You might like to look again at the map on page 152. You can see from this that the average amount of precipitation each year in the United States and Canada varies from 10 inches to over 80 inches.

In some places farmers can count on enough rain falling on their fields each year for them to raise their crops. But in other places farmers must depend on additional water from wells or springs or reservoirs. All this water was also once rain or melted snow. To be of use, it may have to be piped or carried by streams many miles from the place where it originally fell.



Building Dams for Many Uses

One of the largest reservoirs in the United States is Lake Mead, a man-made lake. In the picture you can see the huge dam holding back the water in Lake Mead. This is Hoover Dam in Arizona, built on the Colorado River.

The water stored in Lake Mead comes from the rain and snow that falls on lands along the Colorado River and its tributaries. Some of the water stored in Lake Mead is used by farmers to irrigate their crops.

The water that flows from this lake down into the canyon of the Colorado River produces a great deal of energy. If you should visit Hoover Dam, you would see huge machines called generators that use the energy of the falling water to make electricity. This electricity is used by many people who live in Arizona, Nevada, and Southern California.

Below Hoover Dam there is a system of other dams. The map on the next page shows you some of the smaller dams built along the lower part of the Colorado and on some of the streams that flow into it. Some of these smaller dams are used to store water for irrigating crops. They produce electricity too.

These smaller dams also are used to prevent land from being flooded in the spring. At this time of year rain and water from melting snow

may rush off mountain slopes into streams. The streams become swollen and might flood over the land if there were no way to control the flow of the water. The dams hold back some of the water and prevent floods.

Dams have still other uses. In many parts of the United States and Canada farmers build small dams across streams on their land to make ponds. The water stored in the ponds may be used for cattle and other farm animals to drink. It may also be used for irrigating crops.

Many farmers stock their ponds with fish. The fish provide food for the people living on the farms, as well as sport for those who like to fish. Ponds also provide places for swimming and, in cold parts of the country, for ice skating.

Whether water is useful or harmful to us depends on how well we control its flow. In the past, people have cared little about the source of their water. Yet having a safe and useful supply of water is something that is important to each one of us.

Good soil

Poor soil

Using Soil Wisely

All of us depend on soil. Nearly everything that we eat, use, or wear, as well as the houses we live in, depends on soil. Think of the foods you have eaten today. Probably most of them came from plants. Plants need good soil in which to grow.

The part of the soil in which plants grow is called topsoil. On some land the topsoil may be several inches thick. In other places it may be as deep as 2 feet. Topsoil is a long time in the making. To make just 1 inch of topsoil takes from 300 to 1000 years. Yet 1 inch of it can be carried away by wind or water in a very short time.

Topsoil contains certain mineral elements. Nitrogen, calcium, iron, and phosphorus are some of the minerals found in good topsoil. When topsoil is lost, these minerals are lost also.

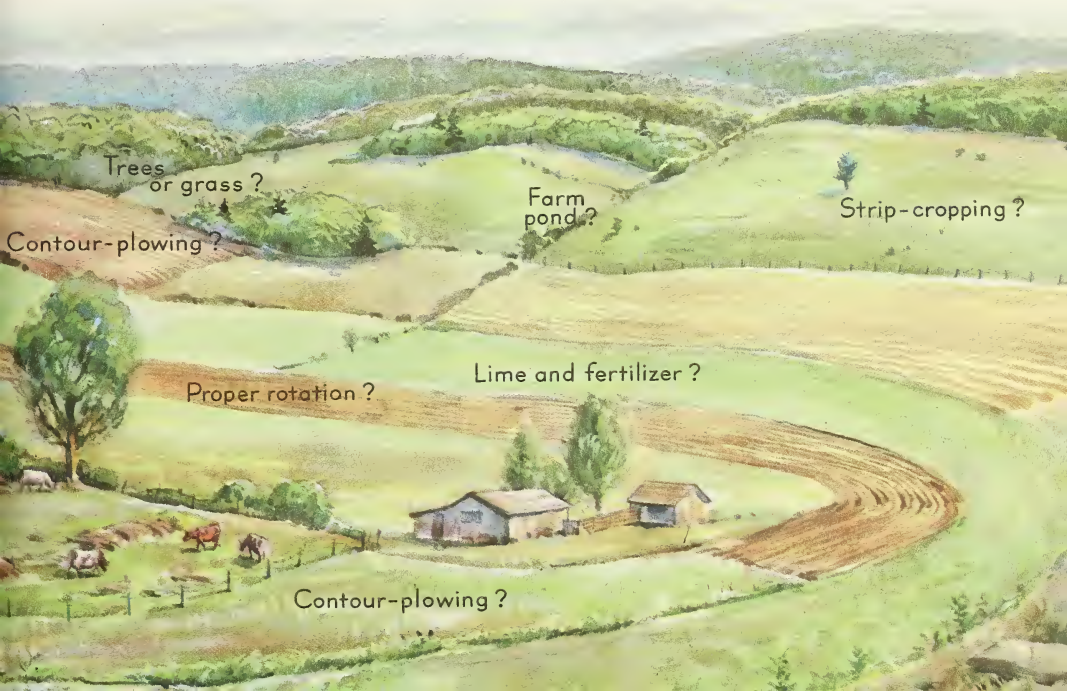
People have experimented with different kinds of plants which we use as foods. They have found that plants grown in poor soil contain smaller amounts of minerals than plants grown in good soil. A stalk of celery grown in poor soil will not contain the same amount of calcium or phosphorus as a stalk of celery grown in good soil. We can see that it is important to everyone that farmers use their land wisely.

A Farmer Makes a Plan

How does a farmer go about making a plan for his land? First, he may ask the Soil Conservation Service to work with him. The soil scientist and the farmer may make a map of the farm. They may use a photograph of the farm taken from the air. The soil scientist helps the farmer plot on the map the different kinds of land on the farm.

After the map of the farm has been made, the soil conservationist and the farmer start on the next part of the plan. They go from one field to another observing the land and how the farmer is using it. Then they check each field with the map and decide the best use to which it might be put.

The farmer tells the soil conservationist what crops he grows, the kinds of animals he has on his farm, and the machinery he has. He also tells what kind of farming he wants to do. The scientist helps the farmer to plan ways in which to keep his land producing good crops. He helps him decide what needs to be done in each field to prevent the soil from being washed or blown away. The picture below shows you some of the questions that might possibly need to be answered.



Ordinary plow

Lister

Good Farming Practices

What are some of the best practices a farmer uses on his land? One way to prevent soil from eroding is to use each acre of land for what it is best suited. For example, some land may be suitable only for raising hay or for use as pasture land. If it is plowed up and used for growing grain, it will be wasted land.

The way in which the land is plowed also has a great deal to do with wise use of the soil. Some plows throw the soil in one direction and form a long, narrow dam. Farmers have learned to plow sloping fields so that no water runs off. These fields are plowed along the curve, or contour, of the land. As the farmer plows round and round his land, the rows form a series of earthen dams. These slow up the flow of water and hold most of the rain where it falls. The soil will not be washed away.

Sometimes a farmer uses another kind of plow, called a lister. It makes a furrow by throwing soil in

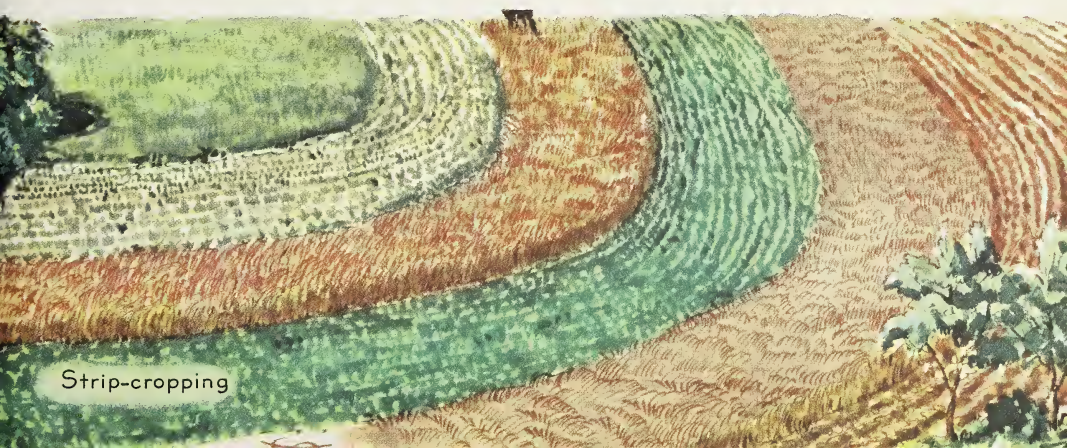
Contour-plowing

Field plowed with a lister

both directions. These furrows keep snow from drifting off the field. When the snow melts, the water does not run off and carry soil with it. When it rains, these furrows hold the rain where it falls; so it will soak into the ground.

Another helpful practice a farmer may use on sloping land is strip-cropping. Strips of close-growing crops, such as wheat, are planted. These alternate with strips of a different type of crop. The strips are planted along the curve of the land.

The farmer in the picture below has strip-cropped his field. He has planted a strip of wheat, then a strip of beans, and then another strip of wheat. His bean and wheat crops will be harvested at different times. Because of this there will be some plants growing continually to hold the soil from washing or blowing away.



Strip-cropping

Farmers have also learned that some crops will enrich the soil by adding nitrogen to it. Alfalfa and clover are two such crops. Others, such as cotton and grain, only remove minerals from the soil.

If a farmer kept on planting the same crops on a piece of land year after year, the soil would soon be worn out. To prevent this from happening, the farmer rotates his crops. If he plans to grow grain for one or two years on a piece of land, he will then plant alfalfa or clover the following year. This is one way in which a farmer puts back into the soil the nitrogen that is necessary for healthy plants.

Using Forests Wisely

There are many things we use each day that come from forests. We use wood to build homes and to make furniture. We are able to have newspapers, magazines, and books because we have learned to make paper from wood. Many of the containers in which our foods are packaged and marketed are made from forest products. What other ways can you list in which forests are important to us?

How well man manages to live on the earth depends a great deal on how well he maintains the forests. The forests of the earth help to enrich our soil and to control our water supply. They affect the amount of water we have to drink, to grow our crops, and to run our industries.

Forest Watersheds

When rain or snow falls on sloping land, the water drains off into nearby lakes and streams. We call such sloping land a watershed. The hills surrounding a lake or reservoir might be called its watershed. This word is also often used to describe a whole region which drains into a river and its tributaries.

The plants that cover a watershed may be almost entirely trees, or there may be shrubs, grasses, or desert plants. Some areas, like the Mohave Desert in California, have few plants growing on them. Yet many watersheds, such as the Great Smoky Mountains of Tennessee and North Carolina, are covered with dense forests. You can see these forests in the picture below.

If you live in a town or city, the water you use may come from a watershed many miles away. The watershed may be steep mountain slopes like those you see in the picture above. It may be gentle slopes like those in the valley you see in the picture below.

Let's suppose that we could visit a well-protected forest watershed. We would soon notice that the temperature of the air in the forest is quite different from that of the surrounding area. If it is summer, the air in the forest is cooler than the air outside. In winter just the opposite is true. The air in the forest is warmer.

The surface of the ground is covered with a thick mat of dead leaves, twigs, and other plant material. If we should carefully lift several handfuls of this loose material away, we

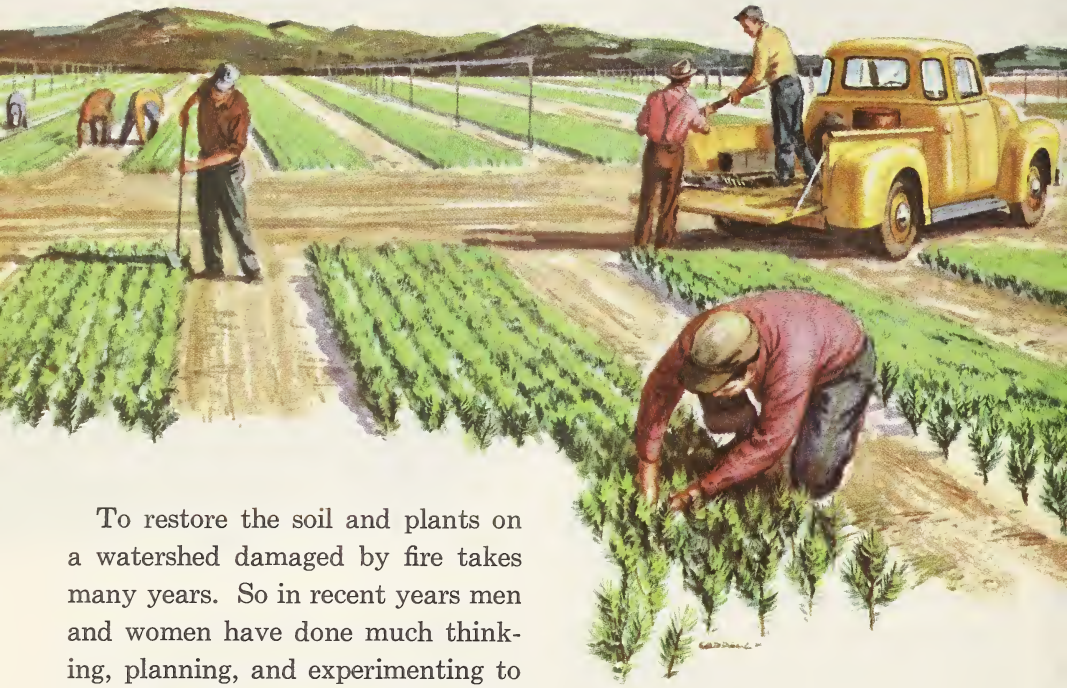
would find a layer of partly-decayed plant life beneath. Below that layer the soil is soft and spongy.

Small animals live in the forest and help to stir up the soil. As they dig and burrow in the ground, they loosen the soil. This helps the water to soak in more rapidly. It also helps to increase the amount of water that the soil can hold. Plant and animal life are very important to a watershed.

If it rains hard or for a long time, a great amount of water falls directly on the ground. Then it moves downward into the soil. Some of this water moves underground and flows into lakes and streams.

Sometimes more rain falls than the soil can hold. Then the rest runs off the ground. On a well-protected watershed little or no soil is carried with the water as it flows into streams. The roots of plants hold the soil in place. So the streams carry clear water to the lands below.

Many watersheds in North America are not giving safe and useful water. These watersheds have been damaged. Fire is one of the worst enemies of a forest watershed. Sometimes just one fire may destroy all plant life in a forest. Animal life in the soil and in the forest may also be killed. Even a part of the soil may be injured. Water running off a damaged watershed may cause floods that destroy farmers' crops and people's property.



To restore the soil and plants on a watershed damaged by fire takes many years. So in recent years men and women have done much thinking, planning, and experimenting to find the best ways to repair damaged watersheds.

Forest Farming

Usually we do not think of trees as being a crop, but they are. However, to raise a crop of trees takes much longer than to grow a crop of something such as corn or wheat. To ripen a field of corn or wheat takes only one year, but trees take many years. It may take as long as 100 years for a tree to grow. Of course we do not have to wait that long. Our forests have trees growing in them that are of all ages.

You have probably walked through a forest and seen small trees a foot or so high growing under tall trees. These small trees are called seedlings. If fire is prevented in the forest, many of these seedlings will grow until they are ready to be harvested.

In some areas where fire has destroyed the trees, people must help the land to a new start by planting seedlings. These seedlings are raised in nurseries from seeds.

The people in the picture above are weeding the beds in a large tree nursery. Here five million young

trees are growing from seed. When the seedlings are large enough, they will be planted on land where the forests have been destroyed by fire.

Seedling fir tree

In some forests many trees are already fully grown and are ready to be harvested. If they were left standing, they would die of old age. When these old trees have been cut, the young trees will have more room and sunlight. They will be able to grow faster.

In other forests most of the trees may be young, but here too certain trees are thinned out. The farmer in the picture below is marking with paint the trees he wants to cut. You can see how close together the trees are growing. By thinning out this forest, the tree-farmer will be able to grow a better crop of trees. The trees may be sold for pulpwood, from which paper, rayon, and wallboard are made. Or they may be cut and used as fence posts.

If most of the trees in an area are of the same age, the tree-farmer will not cut all of them. He will choose

Animals enrich the soil

certain trees as seed trees. The seeds which these trees produce will spread over the area, and new trees will start growing.

It is possible to grow trees in many areas of land which are not well suited to other kinds of crops. On almost every farm there is some land that is not well suited for farm crops or pasture. Scientists tell us that much of this land can support tree growth. If all such land were covered with a rich growth of trees, it would become a productive part of the earth. Barren soil would become useful. It would be an aid in controlling our supply of water.

As trees grow in barren soil, the soil itself is improved. It gradually becomes more fertile. You might

say that a forest has its own fertilization program. Leaves fall each year and enrich the soil. Animals come to a forest area and add wastes to the soil.

Many tiny animals, such as ants, spiders, and earthworms, make their home in the soil in which trees are growing. These animals carry bits of decayed plant life into the ground. As rain soaks into the ground, it carries some of this fertile material down with it. In this way a deeper layer of topsoil is gradually developed.

So you see, the planting of trees and the making of forests is one important way in which man can improve land. In this natural way barren and unproductive areas of land can be improved and made useful.

THINGS YOU CAN DO

1. Consult the Forest Service or Soil Conservation Service about plans for your community. Find out where erosion is taking place. Is there anything that you can do to help prevent it?

2. If you live near a forest area that has been burned, find out all you can about the cause of the fire. How could it have been prevented? Compare the soil here with soil in an undamaged forest. Perhaps you will be able to start some new trees growing in the burned area.

3. Visit several farms. Notice how each farmer uses his land. What methods are used to keep soil from washing or blowing away? What are the advantages of each method?

4. Select a committee to write to the Fish and Game Commission to find out how it protects wildlife in your state or province.

5. If you live in a city, there is probably a park nearby, which you could visit. Has the grass been trampled down? Is any erosion taking place?

6. Perhaps you can find a gully in your community. If you can get permission, you might build a dam across it by using sticks and rocks. This should prevent the water from washing away the soil. When the gully has been dammed, visit it again after a rainstorm to see how much soil has been held back by the dam. You might plant grass in this soil.

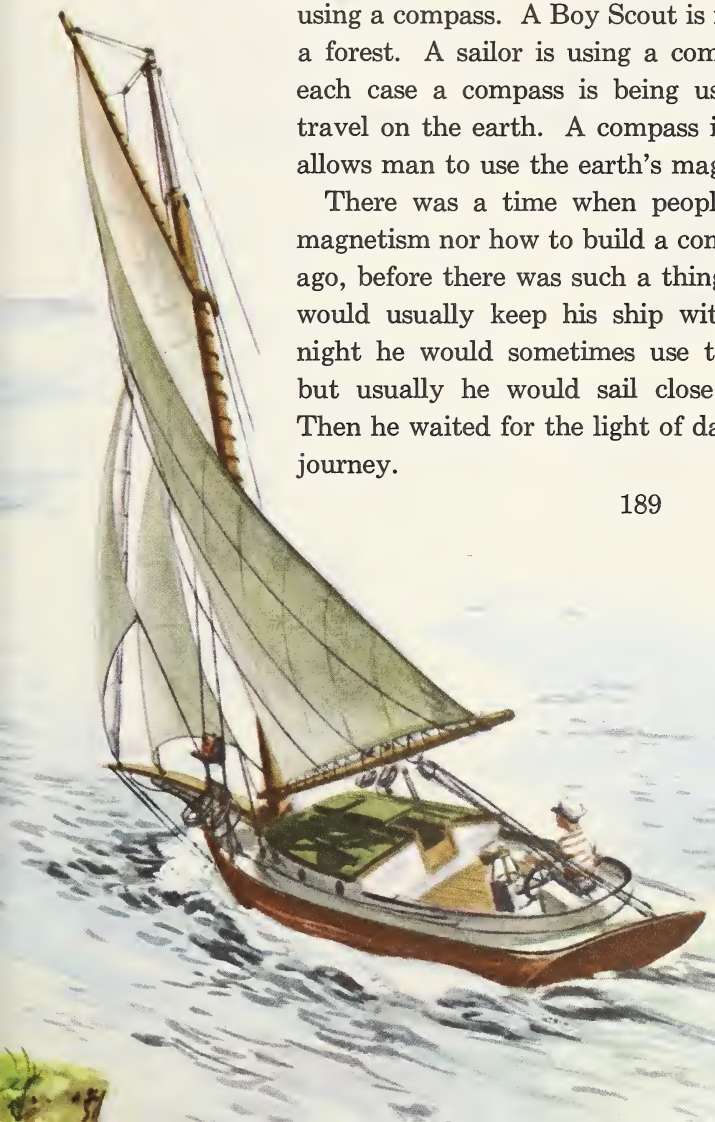
Our Earth—A Huge Magnet?

Using the Earth's Magnetism

Have you ever made use of the earth's magnetism? Perhaps you are not quite sure how to answer this question.

In the picture on these pages you can see people using the magnetism of the earth. Each of these people is using a compass. A Boy Scout is finding his way through a forest. A sailor is using a compass on shipboard. In each case a compass is being used to help the person travel on the earth. A compass is really a device which allows man to use the earth's magnetism.

There was a time when people did not know about magnetism nor how to build a compass. About 800 years ago, before there was such a thing as a compass, a sailor would usually keep his ship within sight of land. At night he would sometimes use the stars to guide him, but usually he would sail close to shore and anchor. Then he waited for the light of day before continuing his journey.



Man made many discoveries about magnetism before he was able to build a compass. But no one is sure when any of these discoveries were made. Long ago someone found that a certain type of rock sometimes attracted iron. The name given to this rock was *magnetite*. When a piece of magnetite acts as a natural magnet, it is often called loadstone.

Later it was found that a piece of this natural magnet would always point in the same directions if it was free to swing. One end of the magnet would point in the direction we call north, and the other in the direction called south.

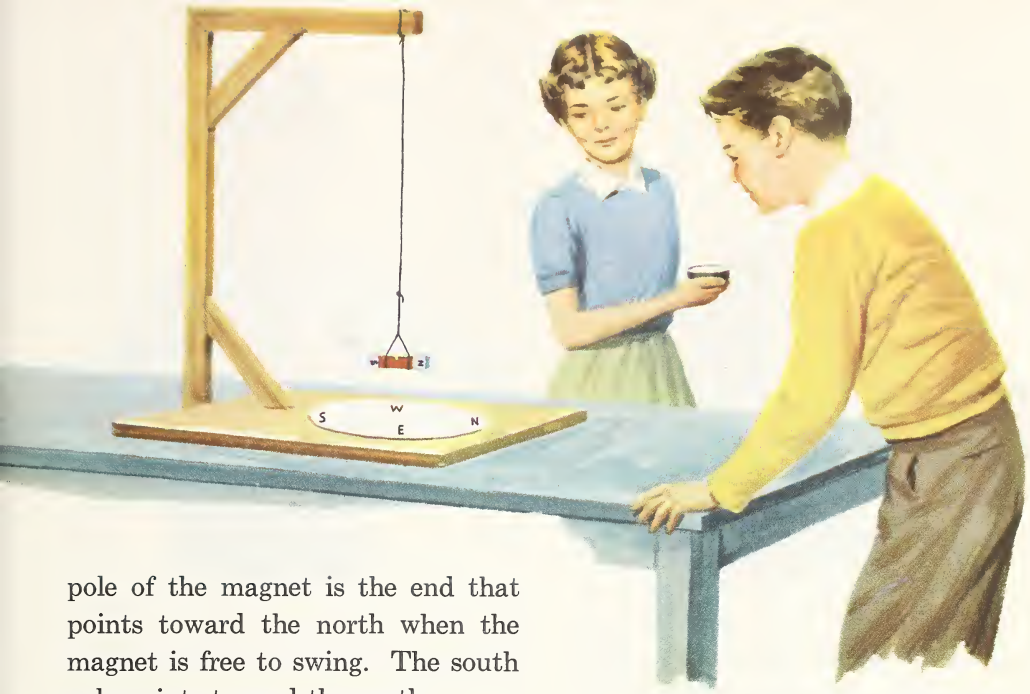
This was useful information. It meant that when a man was lost, he could find his way again by using a magnet. The magnet, when free to swing, would point north and south.

We call such a freely swinging magnet a compass. Compasses were made and used for many years before man had any understanding of how they worked. There have been many different theories about the magnetism of the earth.

Making a Compass

It is not difficult to make a compass. All you will need is a bar magnet and a wooden stand to hang it on.

First, look at the magnet. Often one end of a bar magnet is marked with an *N* and the other end with an *S*. These letters indicate its north and south poles. The north



pole of the magnet is the end that points toward the north when the magnet is free to swing. The south pole points toward the south.

To make a compass, first tie a bar magnet as you see in the picture above so that it will be free to swing. Now cut out a large, circular piece of paper. It should be about 1 foot in diameter. Write *North*, *East*, *South*, and *West* at four points along the edge of the paper, equal distances apart. Place the paper directly under the bar magnet so that the north pole of the bar magnet points to the north position on the paper. Now you have made a compass.

When you have made your compass properly, the words on your piece of paper will correctly show the directions north, south, east, and west. If you have a pocket compass, you can check these directions. Be sure that you do not hold this compass too near the bar-magnet compass you have made. If you should do this, the small compass needle would not point correctly. You will see why later.

Hold the pocket compass steady until its needle becomes stationary. Then carefully turn this compass around until its needle points to the direction marked north on the face

of the compass. Now compare this with the bar-magnet compass you have made. Are the directions the same on the two compasses?

The needle of a compass is really a small bar magnet, mounted so that it can swing freely around. The end of the needle which points toward the north is called the north pole of the compass needle.

Iron Affects a Compass

Men and women who studied the compass were confronted with a puzzling question. What is there about the earth that causes a compass needle to point continually in the same direction? To answer this, they knew that they would first have to find out what affects a compass needle. In one of their experiments they tried bringing a piece of iron near a compass needle, and a very startling thing happened. You can try this for yourself.

Hold an iron nail close to the north pole of a compass needle. Slowly move the nail around the rim of the compass case. You will see that the north pole of the compass needle follows the nail as you move it. Instead of pointing toward the north, the compass needle points toward the iron nail!

Now hold the nail close to the south pole of your compass needle.

The same thing will happen to the south pole as you move the nail.

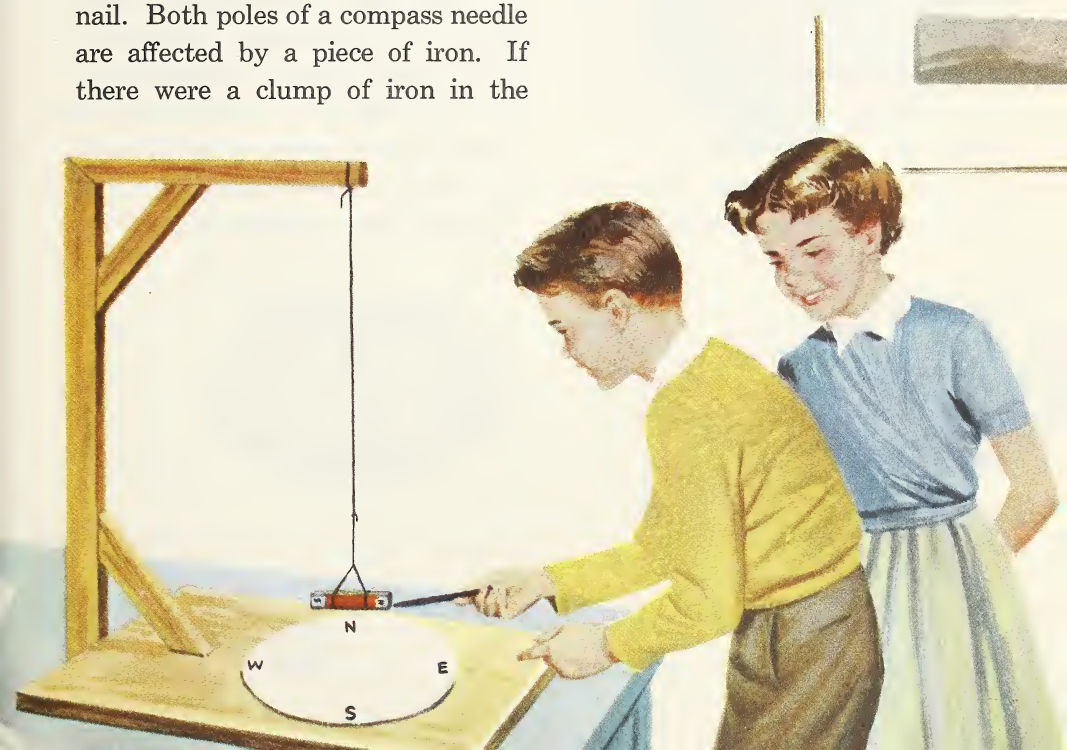
It can be clearly seen that iron affects a compass needle. It was suggested that perhaps the north poles of compass needles point north because they are pointing toward a clump of iron in the northern part of the earth.

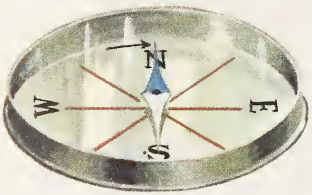
Do you think that this is a good explanation? Think for a minute about your experiment with the iron nail. It is true that the north pole of the compass needle moved toward the nail, but what about the south pole of the needle? That also could be made to point toward the nail. Both poles of a compass needle are affected by a piece of iron. If there were a clump of iron in the northern part of the earth, it would explain why the north pole of a compass needle points toward the north. But why is this not also true of the south pole of a compass needle?

Magnetism Affects a Compass

Scientists wanted a better explanation of the reason why compass needles always point in the same directions. You might try an experiment. You will see that it gives an important clue.

Bring the south pole of a bar magnet near the north pole of a compass needle. Does the compass needle still point to the north? No. It is



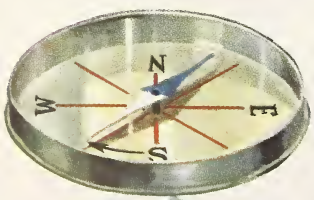


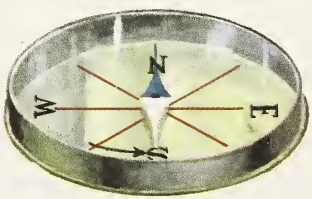
attracted toward the magnet. Take the magnet away, and the north pole of the compass needle swings back toward the north again.

Try bringing this same pole of the magnet near the south pole of the compass needle. The south pole of the compass needle will swing away from the south pole of a bar magnet instead of toward it. When a pole of a compass swings away, we say that it has been repelled.

You will find that the north pole of a compass needle is attracted by the south pole of a magnet, but it is repelled by a magnet's north pole. Do you see what an important clue this is?

Experiments such as this led scientists to say that the earth itself seems to be a huge magnet. They said that the earth must have magnetic poles just as a magnet does. This would explain why compass needles always point in the same directions. It would be because the poles of compass needles are attracted by the magnetic poles of the earth.





Magnetic Poles of the Earth

It is difficult to imagine that the earth is a huge magnet, but you might imagine that the earth has a bar magnet going through it, as you see in the picture at the right. One pole of the magnet is in the northern part of the earth. The other is in the southern part.

Of course there is no such huge magnet in the earth. But scientists have found that the magnetic force on the earth's surface seems to be concentrated in two definite locations, or poles.

You remember from your experiments that the north pole of a compass needle is attracted toward the south pole of a bar magnet. This means that the magnetic pole of the earth toward which the north pole of a compass needle points must be similar in magnetic force to the south pole of a bar magnet. Using certain special instruments, scientists have found such a pole in the northern part of our earth. The name which has been given to it is the north magnetic pole. It has been located on Prince of Wales Island in the Arctic Ocean. This island is off the coast of northern Canada, north of Hudson Bay.

As you can see from the map above, the magnetic north pole is not the same as the geographical north pole. You know that the earth is turning on its axis. One end of the axis is called the geographical north pole. The compass needle points toward a different spot, however. A geographical pole and a magnetic pole are quite different things.

Look at the map below. Do you see the magnetic pole and the geographical pole in the southern part of our earth? You will find that the magnetic south pole is located on Antarctica. The geographical south pole is on Antarctica, too. But you can see that the magnetic south pole is quite a distance from the geographical south pole.

What Is Magnetism?

Men who study the earth have spent much time trying to explain why the earth has magnetic poles. In order to have an explanation of this, they first had to have an explanation, or theory, of magnetism. Then they were better able to develop theories of how magnetism is produced on the earth.

The Molecule Theory of Magnetism

Some scientists gave an explanation of magnetism which was very useful. This theory was built around molecules. You can call it the molecule theory of magnetism.

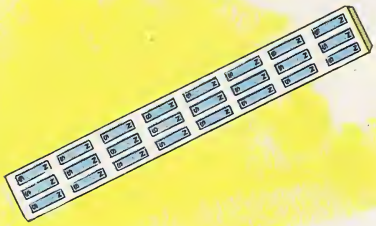
According to this theory all things are made of millions of molecules. You may remember that scientists also say that all things are made of millions of atoms. Perhaps you are not sure just what the difference is between atoms and molecules. We might say that a very small drop of water is made of millions and millions of atoms. It would also be true to say that this same drop of water is made of millions and millions of molecules.

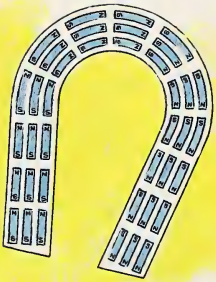
The atoms in a drop of water are not atoms of water. They are atoms of the chemicals of which the water is made. They are atoms of hydrogen and atoms of oxygen. When two atoms of hydrogen combine with one atom of oxygen, they form one molecule of water. This is expressed by the symbol H_2O.

A molecule is the smallest part into which a substance such as water can be divided and still be water. A water molecule is made up of more than one kind of atom. There are about one hundred other substances which are not made up of more than one kind of atom. These substances are called elements.

Hydrogen and oxygen are both elements. Iron is another substance which is made up of only one kind of atom. A small piece of iron consists of millions and millions of molecules, but all the molecules are made up of the same kind of atom. They are all atoms of iron.

The scientists who developed the molecule theory of magnetism said that each iron molecule was a very tiny bar magnet. In this theory each of the tiny molecule magnets would have a north and south pole, just like a large bar magnet.

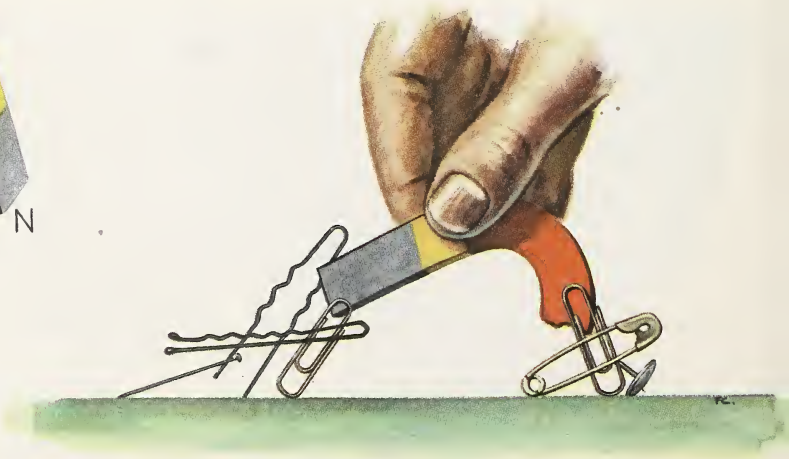




These men said that the molecule magnets in a bar magnet or horseshoe magnet would be arranged as you see in the pictures above. Of course the molecule magnets in a real magnet would be too small to see.

The Molecule Theory Helps

The molecule theory of magnetism helped to explain many experiments. When a magnet is broken in two, the magnet is not destroyed. There are actually two new magnets when this is done. According to this theory, when a break takes place in a magnet, the south poles of its molecule magnets are at one side of the break and the north poles at the other side. You might

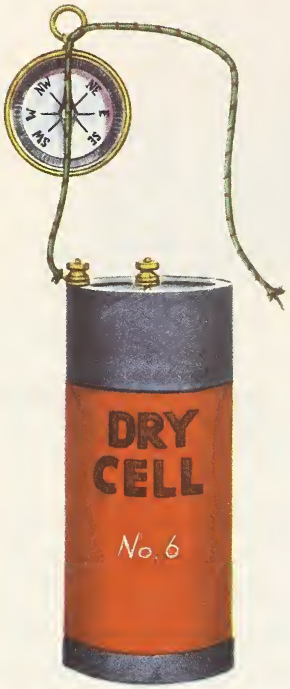


like to try this experiment with an inexpensive magnet, which you can buy in a toy store.

Here is another experiment which the molecule theory of magnetism helped to explain: You will need an iron nail and a bar magnet. Start at the head of the nail and rub one end of the magnet along the length of the nail, as you see in the picture at the right. When you have completed the stroke, lift the magnet from the nail. Then start again at the head of the nail, stroking the nail with the same end of the magnet. By doing this, you will stroke the nail in one direction only. After you have stroked the nail in this way about thirty times, you will find that the nail has become a magnet. You should be able to pick up a paper clip with your magnetized nail.

Remember that the molecule theory stated that each tiny molecule of iron is a small bar magnet. This would mean that any piece of iron is made of small, bar-magnet molecules. In the pictures at the right you will see the way that the molecule magnets of a nail might be arranged. Do you see how the arrangement of molecules has changed after the nail has been magnetized?

According to this theory, after you stroked the nail, the molecule magnets would be arranged so that the north poles all pointed in the same direction. Now the nail would have north poles at one end and south poles at its other end. The nail would be a magnet because of this arrangement of its molecule magnets.



A Change in Theory

The molecule theory seemed to explain many of the known facts about magnetism. But as men and women discovered new facts about magnetism, they began to develop a new theory about it. You might do an experiment which will help you to see what some of these discoveries were.

You will need a compass, a piece of copper wire, and a dry cell. Arrange the wire as you see in the picture on the left above. You will notice that the wire is attached to the outside post of the dry cell and is held over the compass in a north-south direction. Because the needle of the compass is pointing toward the north, the wire is directly above the compass needle.

Now hold the free end of the wire against the center post of the dry cell. Notice the compass needle. It has changed direction! The compass needle now points across the wire.

Disconnect one end of the wire from the dry cell. Electricity no longer flows through the wire above

the compass, and so the compass needle swings back to the north again.

Why does a compass needle move when an electric current flows above it? Scientists knew that one thing which will make a compass needle move is a bar magnet. You can try an experiment with a bar magnet which will show you why this information was very important to scientists.

You will find that there are two ways in which a bar magnet may be brought near a compass to produce the same result as the electric current. Bring the north pole of a bar magnet toward a compass from the west. As you know, the north pole of a compass needle is repelled by the north pole of a bar magnet. The compass needle swings around to the east. It is now pointing in the same direction as when the electric current was flowing through the wire above the compass.

You can also bring the south pole of a bar magnet toward the compass from the east. Does the compass needle move in the same way?

Look at the pictures on these pages. You will see that the results are the same in these experiments. It does not make any difference whether an electric current is used or whether the wire is disconnected and a bar magnet is used. The compass needle moves the same way in either case. But this is the important point: a current of electrical energy can produce the same effect as a magnet.

The Moving Electron

The discovery that a current of electrical energy can produce a magnetic effect was very important. It pointed toward a new way of studying magnetism. As you know, it is believed that a current of electricity is produced by moving electrons. Scientists interested in magnetism began studying the electron.

As you remember, it is believed that the parts of atoms called electrons are electrically charged particles which keep moving rapidly around the center of each atom. While an electron is revolving around the center of its atom, it is moving in another way also. It is spinning, much as a top spins.

It might make you think of the way that the earth moves around the sun. The earth rotates, or spins on its axis, and at the same time it is revolving, or circling, around the sun. In somewhat this same way each electron rotates, or spins on its axis, while it revolves around the center of the atom.

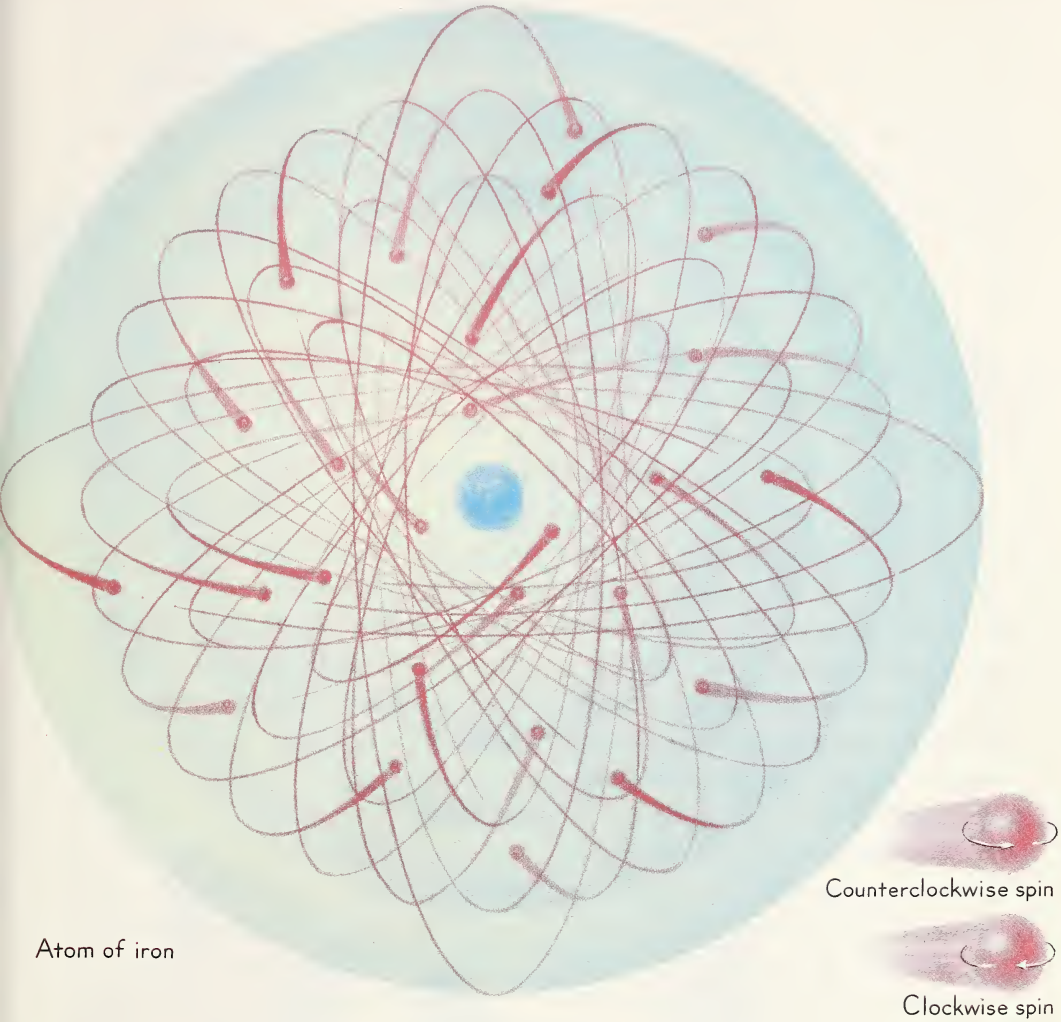
An atom may have many electrons. All these electrons are moving around its center. They are all rotating also, but they are not all rotating in the same direction. Some of them are spinning, or rotating, in a clockwise direction. Some are spinning in a counterclockwise direction.

A piece of iron, such as a bar magnet, is made of many millions of atoms. Each iron atom has twenty-six spinning electrons. This means that there are an extremely large number of electrons in even a small piece of iron.

Some scientists think that these moving, spinning electrons have something to do with magnetism. They believe that in an ordinary piece of iron most of the electrons are spinning in different directions. But they think that in an iron magnet most of the electrons are spinning in the same direction.

Even within the atom the motion of many electrons spinning in the same direction may produce an electric current. In fact, this theory could be called the electron theory of magnetism. According to this theory magnetism is caused by this motion, or current, of many electrons spinning in the same direction.

Can you see how the molecule theory and the electron theory differ? According to the molecule theory any piece of iron is made up of tiny molecule magnets. But a piece of



iron does not become a magnet until these molecule magnets become arranged in the proper order. In the electron theory the molecules of an ordinary piece of iron are not little magnets. Spinning electrons within the iron atoms can cause the iron to become a magnet when most of the electrons spin, or rotate, in the same direction.

The Earth's Magnetism

Scientists who have studied the earth do not always agree on an explanation of the earth's magnetism. However, most scientists say that the earth is magnetic because it is rotating on its axis.

Some people believe that the rapid rotation of the earth has caused the molecules of iron within the earth to be lined up in one direction. In this theory the lining-up of these molecules produces the earth's magnetism. You probably recognize that this theory is based on the molecule theory of magnetism.

Rotation is an important part of still another theory. Have you ever watched water rotating in a basin after the plug has been pulled out? You might fill a sink with water and watch what happens as the water runs out. Do you notice that the water toward the middle is moving faster than the water near the rim of the basin? Something like this may be happening in our earth. The center of the earth may be rotating faster than the outer part of the earth. Not much faster, but some scientists think that there is enough difference in the speed of rotation to produce electric currents in the core of the earth.

Rotation of the earth is an important part of both these theories. You may want to discuss theories

of the earth's magnetism with your friends. In your discussion you should remember that no one really knows what causes the earth to be a magnet.

Attraction at a Distance

We have said that scientists believe that compass needles point north and south because they are attracted by the magnetic poles of the earth. The magnetic poles in the northern and southern parts of the earth are probably thousands of miles distant from where you live. How can they attract your compass needle? Let's do some experiments with a bar magnet which may help to answer this question.

How far away can you hold a magnet and still have a nail attracted to it? In the picture a nail has been placed on a sheet of paper. You can see that a pencil mark has been made beside the nail to indicate its position. A magnet has also been placed on the paper at a fairly large distance from the nail.

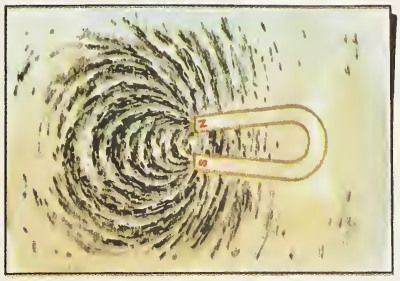
A pole of the magnet should be moved slowly toward the nail. When you first see the nail attracted to the magnet, hold the magnet in place and mark the spot. Now measure the distance between the two marks. This will give you some idea of the distance at which the magnet has an effect on the nail. You can see that a magnet does not have to touch a nail to have an

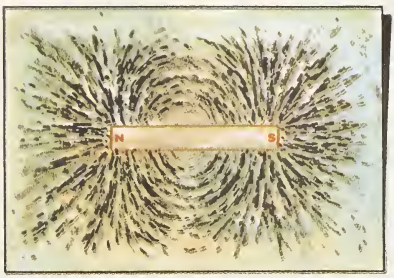
effect on it. We usually say that when an object is attracted by a magnet, it is within the field of the magnet. Let's see what this means.

First, place a small pin on a piece of paper and mark its position. Then slowly move a bar magnet toward the pin. Mark the position of the magnet when the pin is first attracted to it. Leave the magnet in this position, but remove the pin. Now instead of the pin place a rather large iron nail at the mark on the paper where you had first placed the pin. Does the nail move? The field of the magnet must go out this far, because it attracted the pin at this distance. But at this distance the magnetic field does not move the nail.

The field of a magnet may extend for quite a distance, but it becomes weaker as it extends out into space. At a distance the field of a magnet may become too weak to affect a particular object. In your experiment you were able to observe this. You know that the pin was within the field of the magnet, because you saw the pin move. When you placed a nail at this same spot, however, the magnetic field was not strong enough to move the larger, heavier object.

Here is something you can do to get a picture of the magnetic field around a magnet: You will need to have some iron filings for this experiment. Place a magnet on a table and cover it with a piece of





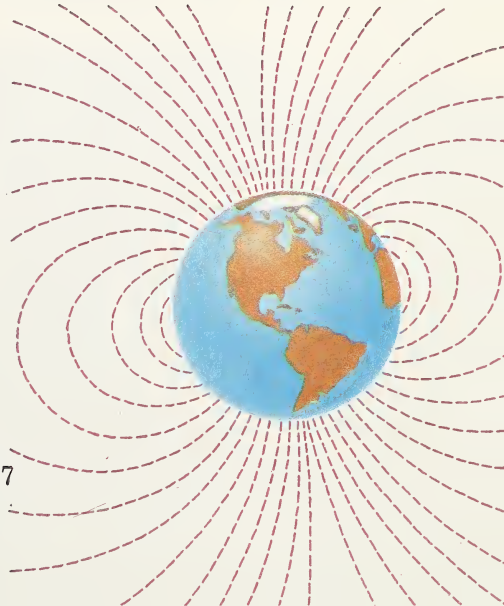
cardboard about 12 inches square. Sprinkle iron filings over the cardboard and gently tap it. Do you see the pattern which they make? Are there filings at the edges of your cardboard which are not affected by the magnetic field? This is because the field is not strong enough there to affect them.

The pictures above show the way that iron filings arrange themselves in the fields of a horseshoe and a bar magnet. Remember that the iron filings do not show the complete field of the magnet. The field actually extends out beyond the cardboard.

The Earth's Magnetic Field

Have you ever stopped to think that you are living in a magnetic field? Scientists believe that the earth produces magnetic effects as though it were a huge magnet. This means that the earth must have a magnetic field. You cannot see it, but you can see its effects. The compass that you use is in the earth's magnetic field with you. Its needle moves and points north and south because the field is strong enough to affect it.

The picture below shows you how scientists think that the magnetic field surrounds the earth. Do you see how the lines of force are concentrated at the magnetic poles?



The earth's magnetic field is strong enough to affect iron objects which it surrounds. You can see this by testing an iron radiator with a compass. Hold a compass close to the top of a radiator. Does this attract the north pole of the compass needle? Then move the compass to the bottom of the radiator. You will find that the part of the radiator closest to the ground repels the north pole and attracts the south pole of the compass needle. The bottom of the radiator has the same effect as the north pole of a magnet. This is because the radiator has been magnetized by the magnetic field of the earth.

The Sun and the Earth's Magnetism

We have known for a long time that there have been changes in the earth's magnetism from year to year. In fact, there are changes during the course of one day. We have learned of these changes because each day the compass needle wanders back and forth by a very small amount.

The change in the direction of the needle is so small that a person using a compass would not even notice it. But scientists in special laboratories are able to observe the changes as they take place.

These scientists have found that the north pole of the compass needle turns a trifle toward the east when the sun rises. During the latter part of the day it wanders a bit toward the west as the sun sets. After the sun sets, the needle resumes its normal position.

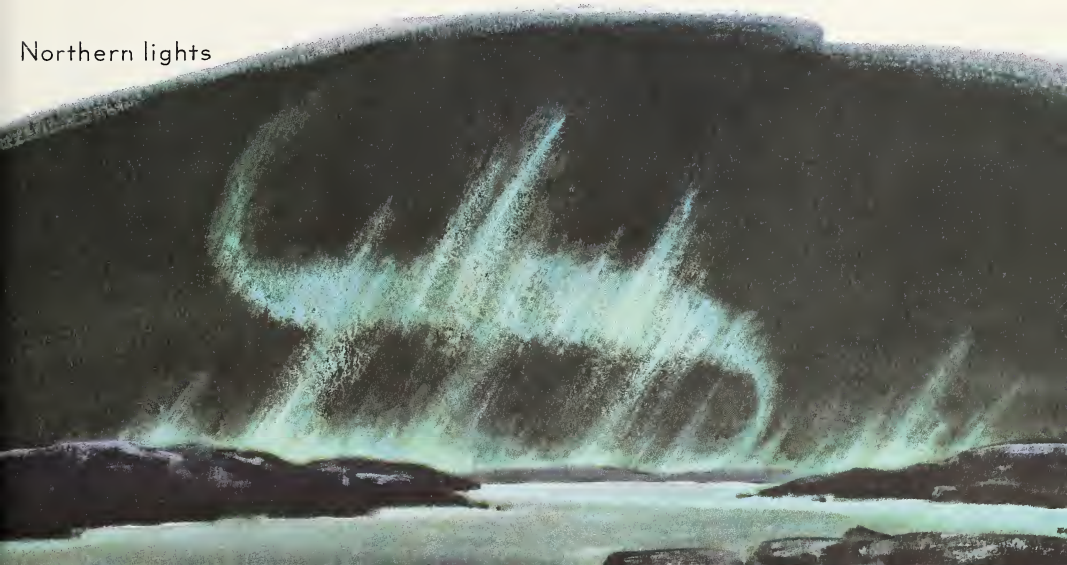
At times there is a still greater change in the needle's direction. It is believed that these changes have some connection with spots on the surface of the sun.

Sunspots are thought to be giant cyclones, or whirlpools, in the sun. No one is sure why or how they are caused, but they seem to have a profound effect on the earth's magnetic field.

It is believed that huge quantities of electrons are shot out from these spots on the sun. Many of these electrons speed from the sun to the earth. When they reach the earth's atmosphere, they sometimes produce the glow which is known in the Northern Hemisphere as the aurora borealis, or northern lights. Sometimes such violent disturbances take place in the earth's magnetism that they are spoken of as magnetic storms.

Sunspots

Man has much to learn about the magnetism of the earth. We have been able to make use of it, but we do not yet fully understand it. We know that it has some connection with the energy of the sun. There may be new discoveries about magnetism which will take place during your lifetime.



Northern lights

LEARNING MORE ABOUT THE EARTH'S MAGNETISM

1. You might try an experiment using the earth's magnetic field. You will need a hammer, a large iron nail, and a compass.

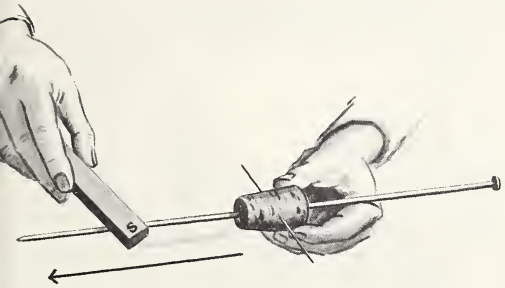
Hold one end of the nail near the north pole of the compass needle. Do the same with the other end of the nail. Is the north pole of the compass needle attracted to both ends of the nail? Now hold the nail in a north-south direction tilted toward the ground, as you see in the picture. Strike the head of the nail with the hammer several times. Then bring the other end of the nail near the north pole of the compass needle. If your experiment has been successful, the needle will move away from this end of the nail. The nail has become magnetized by striking it as it is held in the earth's magnetic field.

2. Your class might like to invite an airplane pilot to your classroom. Ask him about the latest types of compasses. You might also ask him how he uses a compass when flying.

3. Look at the picture at the foot of page 207. Do you see how the lines of magnetic force dip toward the earth? You can find out how the earth's magnetic field is slanted where you live. To do this, you will need to make a special type of magnetic needle. You will need a steel knitting needle, a cork, two darning needles, and two drinking glasses.

Put the knitting needle through the center of the cork. Stick the point of one darning needle into the

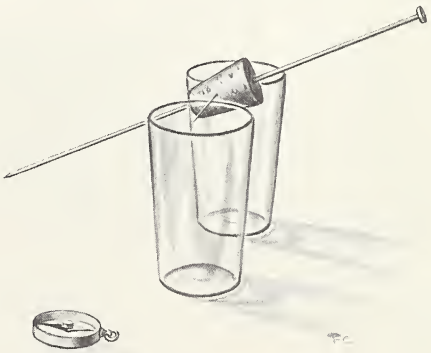
side of the cork. Put it exactly in line with the knitting needle. Do the same with the other darning needle on the opposite side of the cork. Rest the darning needles on the edges of two glasses so that the cork is suspended between them, and the knitting needle is pointing toward the north. Now adjust the knitting needle in the cork so that it balances in a horizontal position as you see in the picture at the right.



To magnetize the knitting needle, use the south pole of a bar magnet. First, pick up the cork carefully, taking care not to disturb the position of the needles in the cork. Now stroke the knitting needle in one direction with the magnet.

When the needle has become magnetized, you can test it to find which end has become its north pole. Bring one end of the magnetized needle near the north pole of a compass needle. Is the compass needle attracted, or repelled? The north pole of the magnetized needle will be the end which repels the north pole of the compass needle.

Now replace the darning needles on the glasses so that the north pole of the magnetized needle points toward the north. If you have replaced it carefully, the north pole of the knitting needle will dip toward the earth. This will show you how much the magnetic field of the earth dips where you live.



Machines to Direct Energy

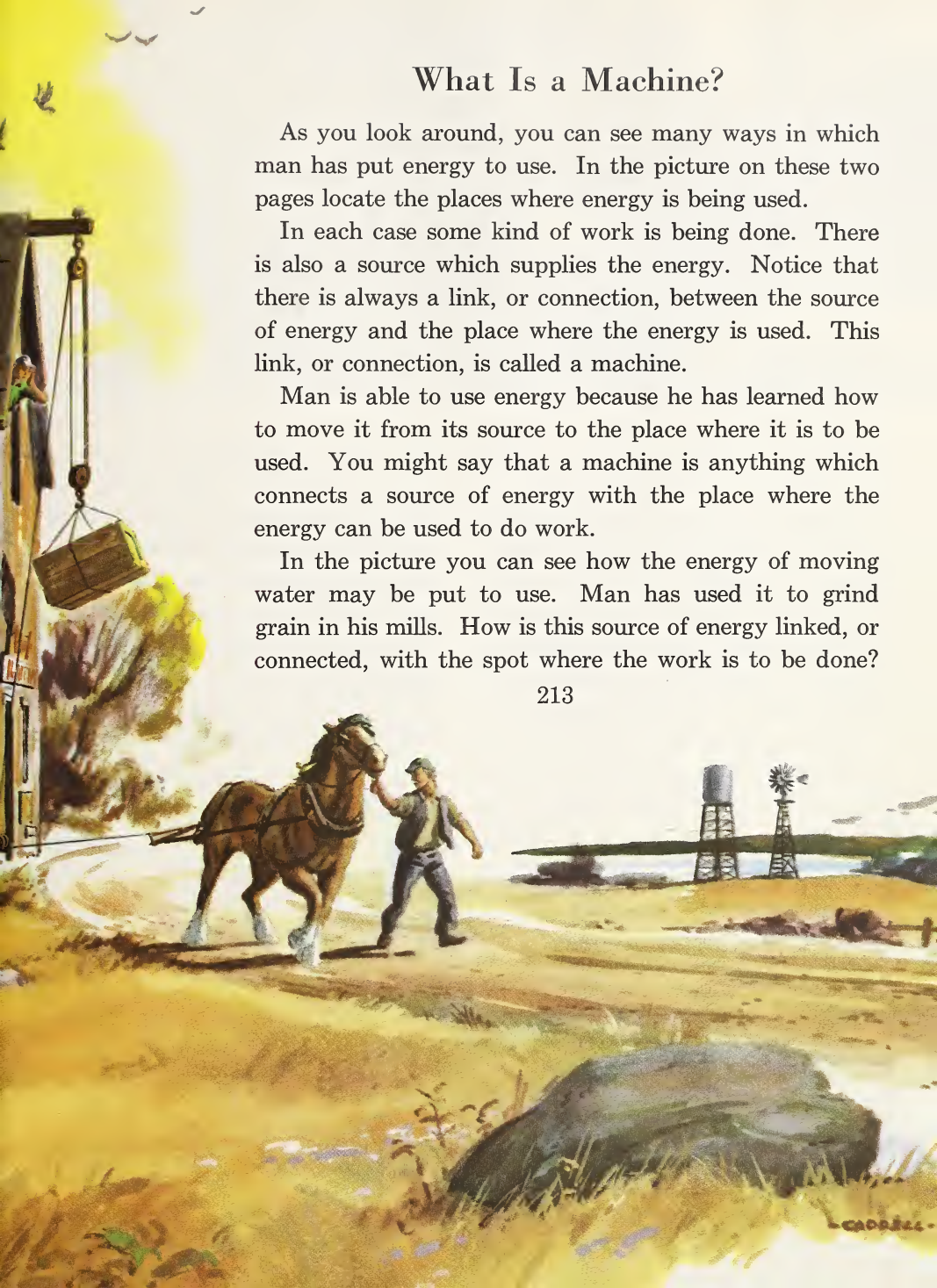
What Is a Machine?

As you look around, you can see many ways in which man has put energy to use. In the picture on these two pages locate the places where energy is being used.

In each case some kind of work is being done. There is also a source which supplies the energy. Notice that there is always a link, or connection, between the source of energy and the place where the energy is used. This link, or connection, is called a machine.

Man is able to use energy because he has learned how to move it from its source to the place where it is to be used. You might say that a machine is anything which connects a source of energy with the place where the energy can be used to do work.

In the picture you can see how the energy of moving water may be put to use. Man has used it to grind grain in his mills. How is this source of energy linked, or connected, with the spot where the work is to be done?



Man Learns to Use His Own Energy

There was a time when people had no man-made machines to help them. The only energy which early people could put to work was their own muscle energy. But you might say that they did have a machine which they used. It was the human body.

As you know, the food which you eat develops chemical energy in the muscles of your body. When you wish to do work, you must direct your muscle energy to the place where the work is to be done. If you wish to move a rock, you may direct your muscle energy to this work by placing your arms against the rock. So the body can be called a machine because it connects energy with the place where the energy is used to do work.

The human body is really a very fine machine, but at first it was the only machine that men had. With only the body machine to use, you can imagine how difficult it was just to keep alive.

Building to Direct Energy

As early man worked from day to day, there was very little that he could do to make his work less difficult. Everything to be done required the use of his own energy.

During his daily travels a man may have noticed that it was difficult to walk up the steep side of a certain hill. One day he may have found that it was easier to move up a side of the hill which had less of an incline, or slope. It was an impor-

tant discovery when man found that it was easier to move along a gradual incline than a steep one.

Even after such a discovery was made, it probably was many years before anyone realized that he could build an inclined path. It may have happened in this way: A large cave may have been found in the side of a cliff. Perhaps the entrance was too high above the ground to be reached. In order to examine the cave, men may have piled rocks below it. It would not be easy to climb these rocks to get in and out of the cave. Someone may have suggested adding to the pile of rocks to make a longer, more gradual incline.

Then as the incline was used, ways of improving it may have been found. Perhaps the incline was lengthened so that it would be more gradual. Small stones may have been used to fill in between the larger stones. This would make a smoother path. Soil may have been packed on top of the stones to make travel over the inclined path easier.

An inclined path has come to be called an inclined plane. When early man first made and used an inclined plane, he had invented a machine. An inclined plane is a machine because it connects a source of energy with the spot where work is to be done. The source of early man's energy was his own muscles. At first the work to be done may have been just to lift himself to high places more easily.

Inclined planes

However, after man had learned to build an inclined plane, he was able to use his energy to do many things which had been impossible before. Objects which could be moved along the ground, but were too heavy to lift, could now be raised. This could be done by building an inclined plane to the desired height. Then instead of having to lift a heavy object, a man would only have to push it along the slope.

An Inclined Plane Helps

You have probably seen and used an inclined plane many times. You may have ridden your bicycle up a hill, and you surely have climbed a flight of stairs. You probably realized that it was easier to climb a gradual slope than a steep one. But perhaps you did not realize that a flight of stairs and a road going up a hill are both machines. They direct your energy so that the work of climbing to a particular height is made easier.

Here is an experiment some boys did: They loaded their wagon with rock and had it weighed on a large scale at a lumber yard. The weight of the loaded wagon was 100 pounds.

One of the men at the lumber yard was able to lift the loaded wagon 1 foot from the ground. He had to use a great deal of muscle energy to lift it. The boys were not able to

lift the wagon, but they found another way to raise it above the ground. To do this, they first built a platform of dirt a bit wider and longer than the size of their wagon. The height of the platform was 1 foot.

Then the boys got two wide planks. One board was 3 feet long and the other was 5 feet long. A board was placed at each end of the dirt platform, as you see in the picture, to form an inclined plane. The inclined plane formed by the 3-foot board was steeper than that formed by the 5-foot board.

The boys fastened a spring balance to the handle of the wagon and took turns pulling the wagon up the 3-foot board. They pulled just enough to keep it moving up the board. The scale on the spring balance indicated that they were pulling with a force of about 34 pounds.

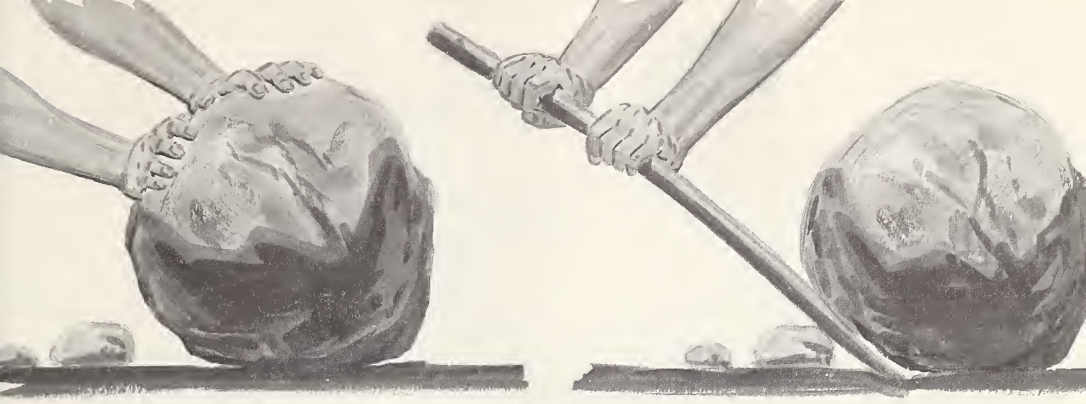
Then they repeated the experiment, but this time they pulled the wagon up the 5-foot board. They found that they had to pull with a force of only about 20 pounds to move the wagon up the longer board. It was easier to pull the wagon up the longer board than the shorter one because the longer, more gradual slope allowed them to spread the work out over a greater distance.

When the man lifted the wagon, he pulled with a force of 100 pounds for a distance of 1 foot. By pulling the

wagon up the 5-foot incline, the boys were able to pull with a force of only about 20 pounds, but they had to pull the wagon a longer distance. When they pulled with a force of about 20 pounds a foot for a total of 5 feet, they had to use about the same amount of muscle energy as the man. They were able to use their energy more slowly, however, and to spread out the work they had to do.

Later the boys tried the same experiment with a different wagon. When this wagon was loaded, it too weighed 100 pounds. But when the boys pulled this wagon up the two inclined planes, they found that they had to pull with a somewhat greater force than before. They decided that the amount of friction that had to be overcome made the difference. There was more friction when the second wagon was used than there had been with the first. But it still was easier to pull the wagon up the gentle slope than the steep one.

You might say that you can't get out of using energy. You can use a machine, such as an inclined plane, to do a little work at a time. It makes the work seem less difficult, but in the end you use the same amount of energy. Of course the machine also allows you to do things you might not otherwise be able to do.



Man Concentrates Energy

In addition to the inclined plane, early men invented other ways of making their work less difficult. No one knows exactly when or how these discoveries were made. Another important discovery may have been made at about the same time that men were learning to use the inclined plane.

Perhaps men were moving rocks to build an inclined path. Someone may have pushed with a stick at a rock that would not move. The stick may have slipped and become lodged under the rock.

As the stick was pulled to free it, the rock may have moved. Such a happening would have been truly astounding. Probably the stick was pushed under the rock again in order to find out whether this really would cause the rock to move. Now each time a man had to move a heavy rock he could use a stick to make the work less difficult. With it he could move rocks which he had not been able to move before, even with all the energy that he could muster. To this early man the stick must have seemed to multiply his energy.

A stick used in this way has come to be called a lever. A lever does not really multiply energy. Instead it concentrates the energy in one spot. You might say that the lever gathers the energy so that the greatest possible amount of work can be done with it. All the energy necessary to move the rock was in the muscles of that early man. The muscle energy of the man really moved the rock. The lever allowed the man to direct and concentrate his energy so that it would be at the right place at the right time.

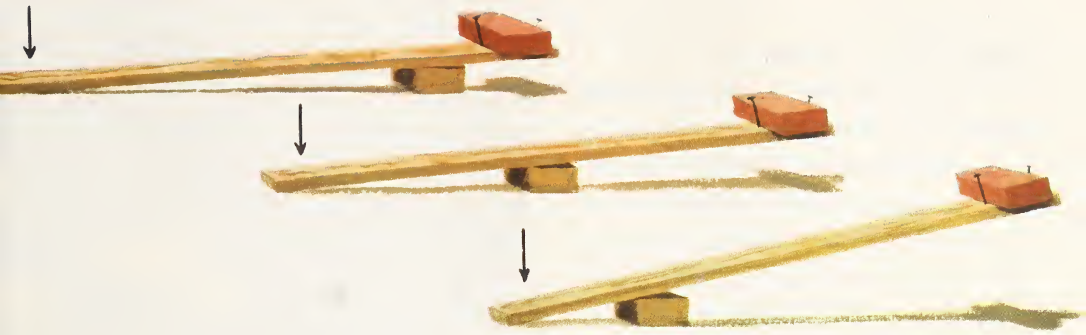
How Levers Work

Like the inclined plane the lever is a machine which connects a source of energy with the spot where work is to be done. The following experiments may help you to understand how levers work. You will need a board about 3 feet long, 3 inches wide, and $\frac{3}{4}$ inch thick. You will also need a block of wood about 6 inches long, 4 inches wide, and 2 inches thick. In addition you should have some nails and a brick.

After you have gathered your materials, place the brick on one end of the board. Drive two small nails into the board on each side of the brick as you see in the picture. Hold the brick in position and place the board so that its center is over the block of wood. Now use the board as a lever by pushing down on its upper end. The brick will rise into the air. You are lifting the brick by using your muscle energy.

You might push down on the board again and ask someone to measure the distance through which the brick moved. Then let the brick down on the table again and measure the distance from the table to the upper end of the board. This will show you how far your hand moved. You will need to keep a record of these two figures.

The point where the board rests on the block of wood is called the fulcrum of the lever. How well a lever works depends partly upon the



distance of the fulcrum from the source of energy and from the work to be done. When your hand and the brick are about equally distant from the fulcrum, you will probably find that they move about the same distance through space.

Let's change the distances between the brick, the fulcrum, and your hand. Move the block of wood so that it is halfway between the center of the board and the end where you put your hand. Now the brick is farther away from the block of wood than your hand is. Lift the brick again to the same height as before. Is it more difficult to lift this time? Notice that although the brick has moved as far as before, your hand has moved through less space.

You can experiment with the block in different positions. You will find that when the brick is nearer the block of wood than your hand is, your hand will move farther through space. This spreads the work out and makes the brick easier to lift.

In the picture below are several different levers you may have used. Look for the source of energy and the fulcrum in each. What is the work to be done?

Man Reduces Friction

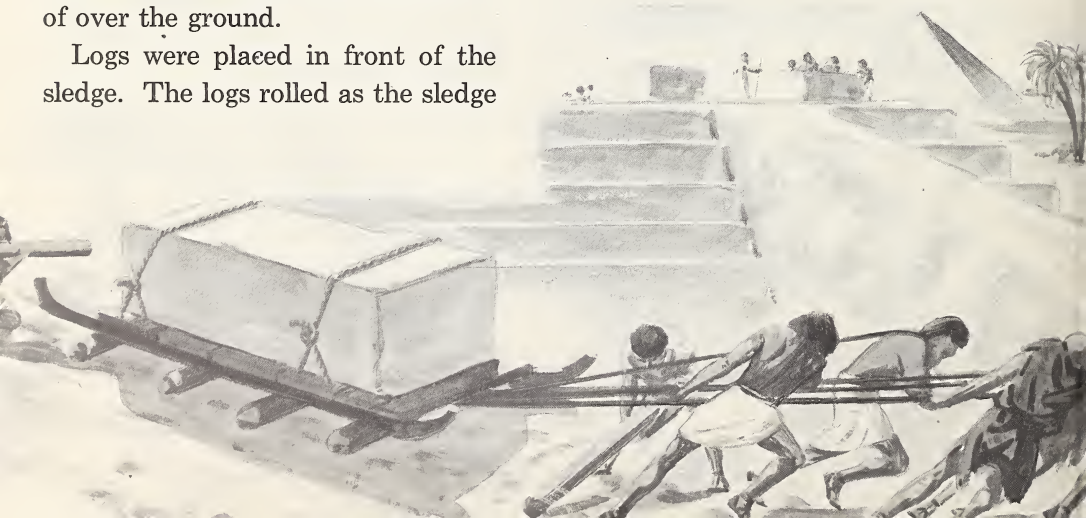
Both the inclined plane and the lever were basic machines used by early men to make work less difficult. But it still took a great deal of muscle energy to move things along the ground or on an inclined plane.

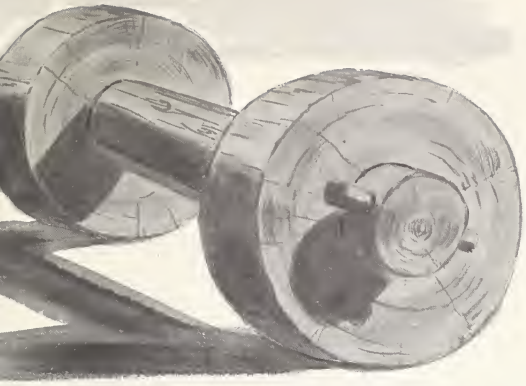
Part of early man's day-to-day work was hunting for food and gathering firewood. Probably his next big invention came from the desire to make this work less difficult. Someone may have found that it was easier to move food or firewood when it was piled on branches of trees which had been tied together. It was less difficult to pull things on this crude sledge than to carry or drag them over the rough ground.

The sledge was one of man's early attempts to reduce friction. His next successful attempt was when he pulled the sledge over logs instead of over the ground.

Logs were placed in front of the sledge. The logs rolled as the sledge was pulled over them. After the sledge passed over them, they were picked up and put in front of it again. This had to be done many times as the load was moved along. Even though it was slow, hard work, it was easier to use log rollers than to drag huge loads over the ground.

For many years men used a sledge and rollers to move heavy loads. Gradually, over a long period of time, changes were made in the rollers. It was found that a log with a wide diameter made a sledge move more easily than a log with a small diameter. It was very difficult to handle large logs. So the larger logs were cut into disks and these were attached to each end of a smaller log. The wide diameter of the large disks made rolling easier.





In the picture above you can see how a small log would be raised by the addition of a large disk to each end. At first each disk was attached to the log so that when the disk turned, the log also turned. The log would have to be replaced in front of the sledge after the sledge had been pulled over it.

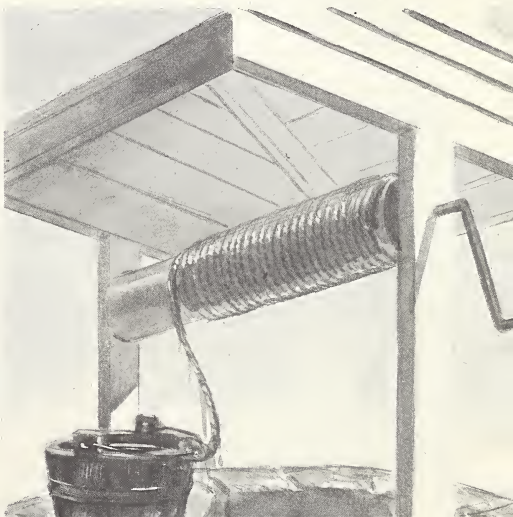
You have probably thought that this combination of disks and log looks very much like wheels and an axle. You are right! It took a long time, however, before someone realized that the disks could be attached so that they were free to roll whether the log turned or not. Then the log could be fastened to the sledge. These disks were the first crude wheels. No doubt they were heavy and bumped along the road, but it was easier and quicker to move the load when wheels were used.

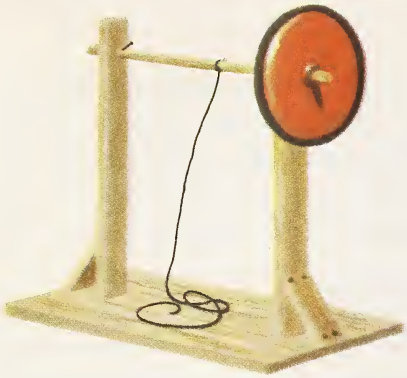
Today much of our daily living is affected by this early invention. Wheels play a major role not only in our transportation, but in our homes and factories as well.

A Windlass

In the picture below you can see a kind of wheel and axle called a windlass. It can be used to lift a bucket of water from a well. A complete turn of the wheel causes the rope to wind once around the axle. As the wheel turns, the bucket comes nearer the top of the well. To lower the bucket, the wheel is turned in the opposite direction.

You might make a windlass with which to experiment. You will need a wooden base and two pieces of wood about 24 inches long for the side pieces. For the wheel of the



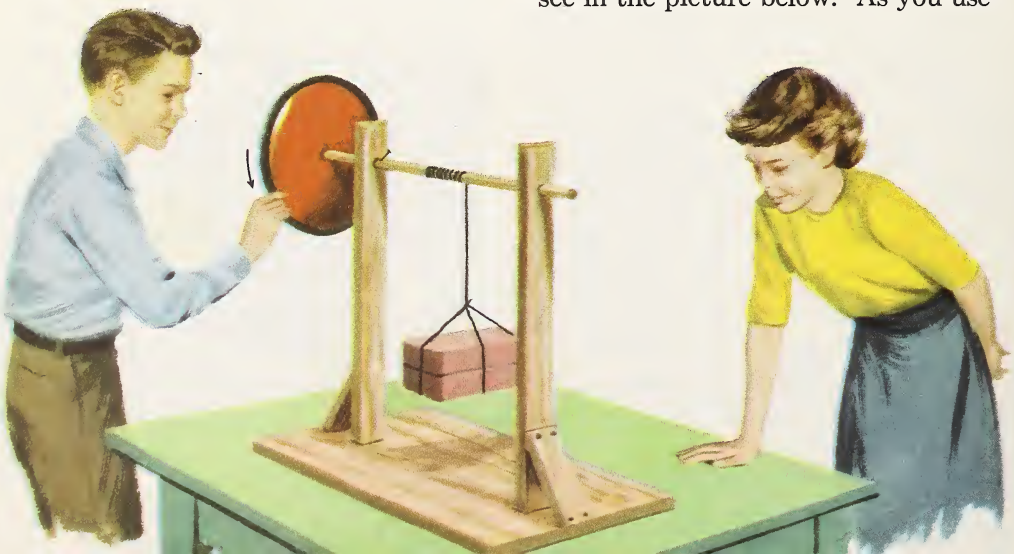


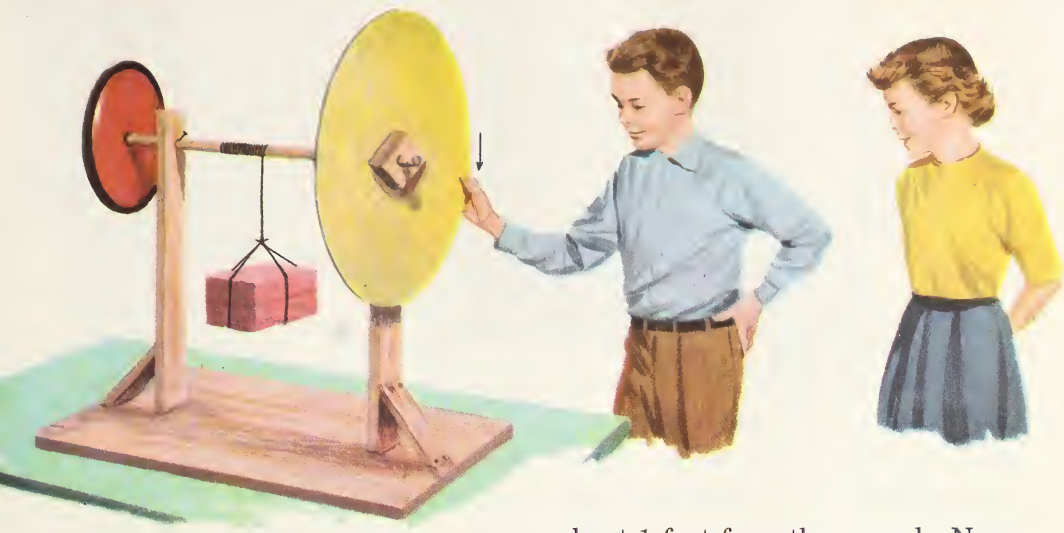
windlass you can use a disk of wood or a discarded wheel from a wagon or bicycle. A wooden rod such as a piece of a broomstick will serve very well as the axle. It should be about 18 inches long. You will also need some nails, rope, and two bricks.

First, bore a hole about 2 inches from one end of each of the wooden side pieces. Make the holes large enough for the wooden rod to move freely in them. Next nail these pieces of wood to the base in an upright position, just as you see in the picture at the left.

A wheel should be attached to one end of the rod so that when the wheel turns, the rod also turns. Now insert the rod in the holes which you bored. It would be a good idea to drive a nail part way into the rod on each side of the upright pieces. These will keep the rod from slipping through the holes. Then fasten a piece of rope to the rod with a nail. Turn the wheel several times to wrap some of the rope around the rod.

Now the windlass is ready to use. You can raise books or other weights with it by attaching them to the rope. Tie two bricks together and attach them to the windlass, as you see in the picture below. As you use





your muscle energy to turn the wheel of the windlass, the bricks will be moved upward. Of course you know that the wooden rod forms the axle of the windlass. Each turn of the wheel raises the weight one turn of the axle.

You can try an experiment with a second wheel. One wheel should be larger than the other. The diameter of the larger wheel should be about twice that of the smaller. As you can see in the picture, the small wheel is attached to one end of the rod and the larger wheel to the other end.

Now you can raise the bricks by turning either one of the wheels. Use the smaller wheel to raise them about 1 foot from the ground. Now use the larger wheel to raise them the same distance. Do you notice a difference as you turn the wheels? With which wheel is it easier to raise the bricks?

You may be surprised to find that it seems to be less difficult to raise the bricks with the larger wheel than with the smaller wheel. Hold your hand on the rim of the larger wheel and make one complete turn. Do the same with the smaller. To make one turn of the larger wheel, you must move your hand through a greater distance than when you make a turn of the smaller wheel. For each turn of either wheel the bricks are moved the same distance, because each raises the weight one turn of the axle.

Remember it takes a certain amount of muscle energy to raise the bricks 1 foot from the ground. You use the same amount of energy to raise them no matter which wheel you turn. If you use the larger wheel, you use your energy more slowly and over a longer distance. This makes it seem easier to do the work.

Experimenting with Basic Machines

We have read that early man invented the inclined plane, the lever, and the wheel and axle. These three are all basic machines. There are three other basic machines: the wedge, screw, and pulley. Each of these machines was invented thousands of years ago.

Most people usually call these the six simple machines. We have called them basic machines because all others are made by combining these six. The invention of the six basic machines gave man a way of directing and using his energy more effectively. These inventions are probably the most important which man has ever made.

Each of the six inventions took many hundreds of years to produce. Probably many men had a part in producing them.

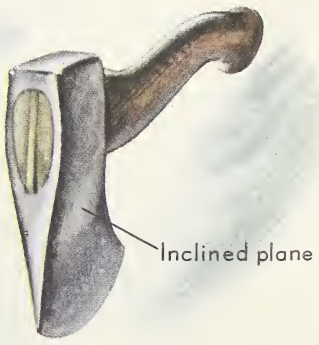
The Wedge

A wedge is one of the basic machines. You will be able to define it for yourself after examining one. Look at a knife blade. Press one side of the blade flat against a table. You can see that the blade slopes up from its cutting edge to form an inclined plane. Now turn the knife over and look at the other side of the blade. It too forms an inclined plane. A knife, then, has two inclined planes. It is a wedge.

All wedges work in the same way. They work by pushing and prying something apart. When you cut meat, the sharp edge of the knife opens the meat or pushes it apart. Then the inclined planes pry the two sides still farther apart.

In cutting down a large tree woodsmen use a wedge that they drive into the crack made by the saw. The sides of the wedge help to push the wood apart. Then it is easier to saw the tree. The ax you use in chopping down a tree or splitting wood for kindling is also a wedge. It would be very difficult to get these jobs done without the use of this basic machine.

Some wedges are easier to use than others. A long, thin wedge is used more easily than a short, thick one. You can find this out by making



two wedges and using them. Cut two wedges out of wood like the ones you see at the left. Wedge A and Wedge B should be the same thickness at the thick end. But Wedge B should be longer.

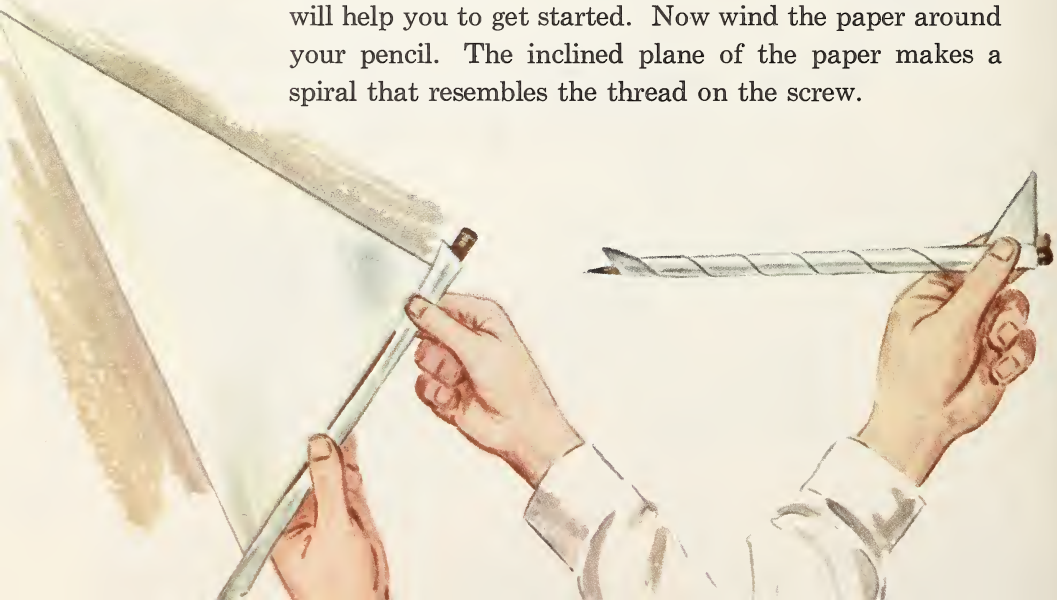
Take the two wedges out of doors and with a hammer pound them into the ground. You will find that it is easier to pound Wedge B into the ground. How would you explain this? Remember that the thick end of Wedge A is the same thickness as that of Wedge B.

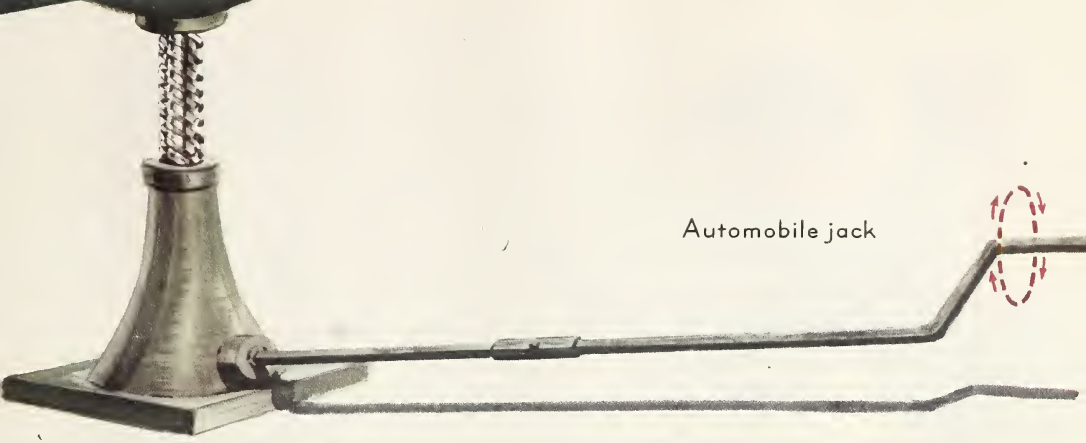
The Screw

If you look at a screw, you will see a tiny strip of metal that winds along it. This is called the thread. Here is something you might do to learn more about the thread of a screw:

Take a sheet of paper and draw a line from one corner to the opposite corner. Now cut along the line you have drawn. You will have two pieces of paper that have three sides each. One side looks like an inclined plane.

Hold the short side of one of the pieces of paper against the length of your pencil. The drawings below will help you to get started. Now wind the paper around your pencil. The inclined plane of the paper makes a spiral that resembles the thread on the screw.





Look at a bolt and nut. You can see the thread winding around the outside of the bolt. Now look at the nut. The threads are inside the nut. Put the nut on the end of the bolt and begin turning it. It moves forward along the bolt. Now turn it in just the opposite direction. The nut moves backward.

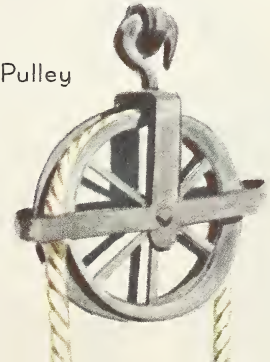
Some automobile jacks work in much the same way as the bolt and nut. The screw in the jack fits into a hollow tube. The tube has threads inside it, just as the nut has. The screw moves upward along the threads inside the tube. It moves in the same way as the nut moves forward on the bolt.

As the screw moves upward, it raises the car. To lower the car, you turn the handle of the jack in the opposite direction. The screw moves downward in the same way that the nut moves backward on a bolt.

The screw is a basic machine, which man has invented to direct his energy. When man uses the screw as a machine, he can direct energy in such a way that work seems to be less difficult.

How Pulleys Work

If you look closely at the pulley used in moving a flag to the top of a flagpole, you'll see a small wheel. The wheel has a rim on each side of it. This prevents the rope from

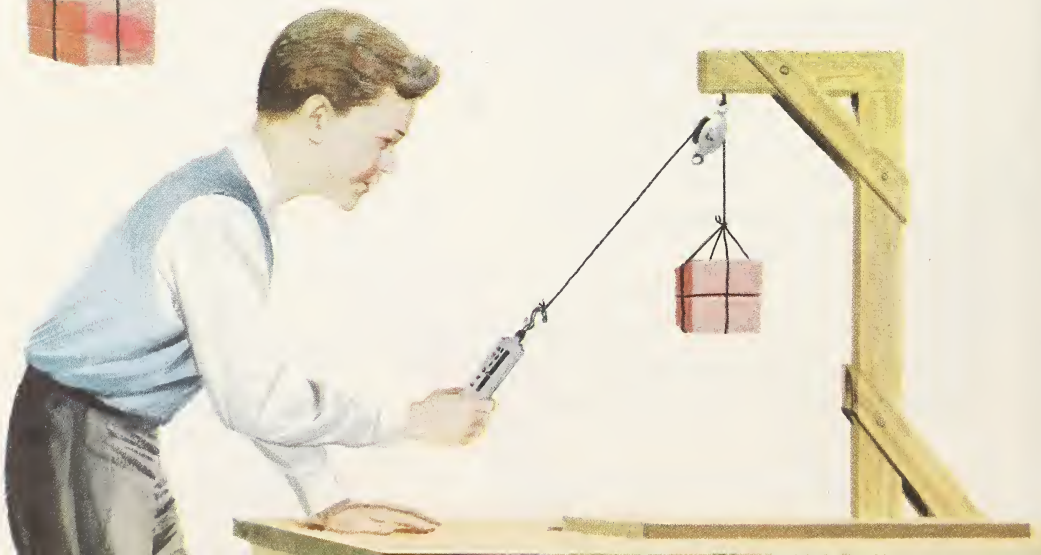


slipping off the wheel. As the rope moves smoothly over the wheel, the wheel turns. If you wish to experiment with pulleys, first make a support like the one you see in the picture at the left. You may attach it to a wall or build a stand for it. Next fasten a pulley to a hook on the support. Put a rope over the pulley wheel. Now you are ready to begin your experiments.

Tie two bricks together and fasten a spring balance to them. Lift the bricks about 1 foot from the floor. Look at the spring balance to see how much the bricks weigh. This will tell you how much force you used in lifting them.

Then tie the bricks to one end of the rope you put over the pulley. Tie the spring balance to the other end of the rope, as you see in the picture below. Lift the bricks about 1 foot from the floor by pulling down on the spring balance. Notice that you have to pull the rope a distance of about 1 foot to lift the bricks 1 foot.

Read the weight on the spring balance. The weight is about the same as when you lifted the bricks without the help of the pulley. But when you lifted the bricks, you had to pull up. When you used the pulley, you



pulled down. Used in this way, the pulley is a machine with which you have directed your energy so you could pull down instead of up.

You will need to add another pulley to do the next part of the experiment. The picture at the top of the page shows how to use two pulleys. The rope is tied to the bottom of the single pulley. Then it goes down and around the second pulley. The rope then goes up over the wheel of the single pulley and is fastened to the spring balance. The bricks are fastened to the second pulley.

Now you are ready to lift the bricks. Pull the spring balance toward you. Lift the bricks about 1 foot from the floor, just as you did before. Look at the spring balance to see how much force it takes to lift the bricks. You will use about one half the amount of force you used before. But notice that you had to pull the rope twice as far.

In both experiments you lifted the bricks by using your own muscle energy. To lift the bricks 1 foot takes a definite amount of energy. So you used the same amount of muscle energy in both experiments. With the two pulleys the spring balance registered only half the force, but you had to use that force through twice the distance. So you use as much energy in the end. But the two-pulley system allows you to spread the work out and it seems less difficult.

Complex machine

Energy Where Man Needs It

Energy is most helpful when it can be moved to the place where it can be used to do work. Even man's own muscle energy would be of little value if he could not direct it by use of his body machine. The six basic machines give us ways of directing our energy. They allow us to do a little work at a time. When we spread the work out, it seems less difficult. Our energy is used to better advantage.

At first man used the basic machines to direct his own energy. Then by making combinations of these basic machines, he found that he could direct energy from other sources.

In time he became aware that he was surrounded by great quantities of energy. He felt the force of the wind. He saw the rush of moving water. He became aware that wind and water were sources of energy that he could use. To use them, he had to be able to direct the energy to the place where work was to be done.

A machine made by combining basic, or simple, machines is called a complex machine. With complex machines man is able to direct energy from many different sources to do his work. What basic machines do you find in the picture above?

LEARNING MORE ABOUT MACHINES

1. In the picture you can see a power shovel which man is able to use for many different jobs. As you can see, it is being used to remove soil, and with each scoop of the shovel a lot of work is being done.

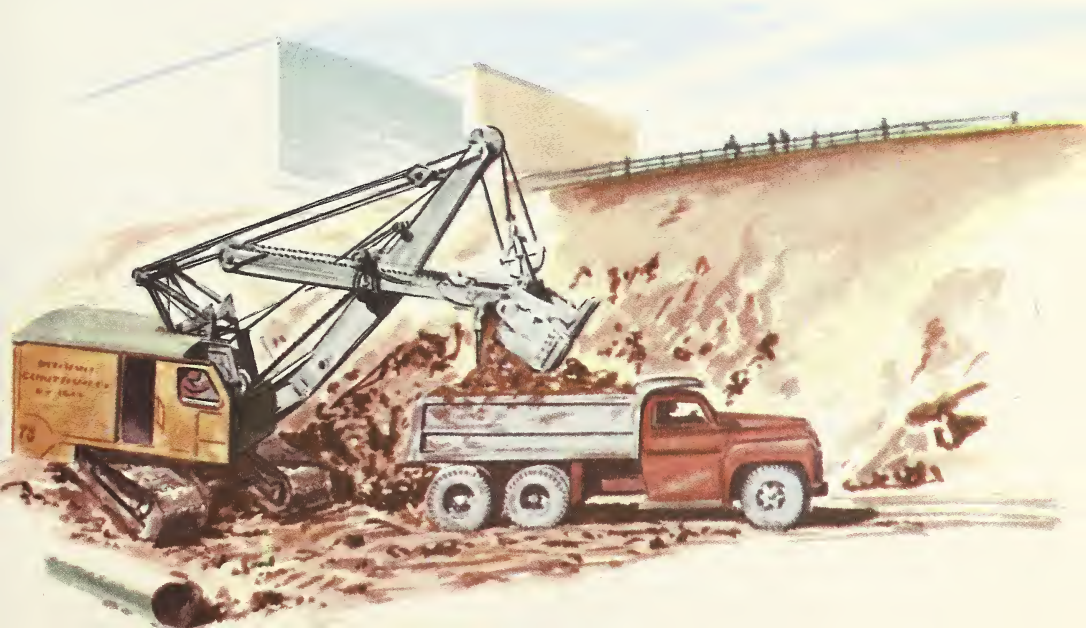
What is the source of the energy which man is putting to work? How is he directing the energy to the place where the work is being done?

The power shovel is a complex machine which man uses to direct the energy from fuel to do work. What are some of the basic machines which have been combined to make this complex machine? You might begin by examining the shovel arm. What kind of basic machine is it?

2. Examine some other complex machines. What work is done with the machine? What is the source of the energy which is used to do the work? What combination of basic machines is used to direct the energy to the place where the work is done?

3. You might examine a pair of scissors and a nutcracker. Each of these simple machines is a lever. Where is the fulcrum and the source of energy? What is the work to be done?

4. A wheelbarrow is a combination of two basic machines: the wheel and the lever. Of course the wheel is easy to see. But can you find the lever?



The Earth's Airways and Beyond

Man and the Air Around

In recent years man has lifted himself from the ground! He has found ways of moving through the air.

Balloons, dirigibles, airplanes, helicopters, "jets," and rockets are all very familiar to us. Fifty years ago, however, during your grandfather's boyhood, many of these things had never been heard of.

Now almost everyone talks about flying. Whenever we look toward the sky, we may see an airship of one kind or another.

Man found a new freedom when he took to the air. High mountains, jungles, and wide seas had always made it difficult for him to travel. Trips from one part of the earth to another used to take long periods of time. Today, in some of our fastest airliners, it only takes a few hours to go from San Francisco to New York. As the air-traveler looks down from the sky, he sees a vast landscape made up of mountains and other obstacles, which used to make travel over the earth so difficult.

Airplanes—How They Fly

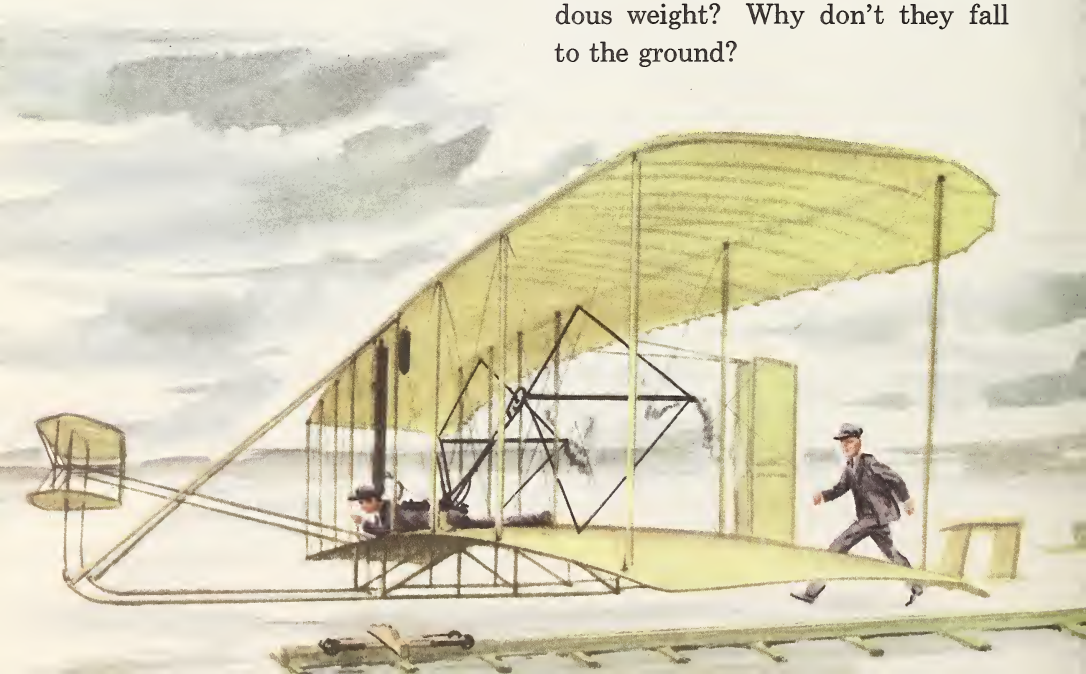
The first successful flight of an airplane took place in 1903. Two brothers, Orville and Wilbur Wright, were the men who made the flight possible. This great event took place at Kitty Hawk, North Carolina.

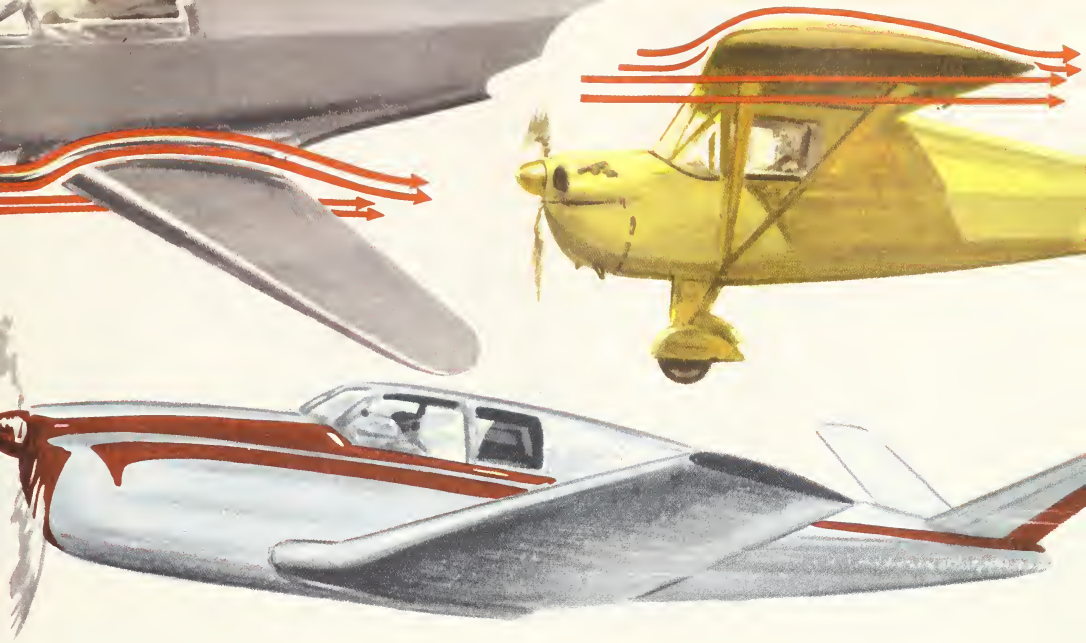
More than 100 years earlier, the first passenger balloon had been flown successfully. Balloons are able to rise above the ground because they are filled with gas that is lighter than air. Dirigibles too rise because the gas which they contain weighs less than the surrounding air.

The airplane flown by the Wright brothers differed greatly from previous aircraft. No lighter-than-air gas was used to lift this airship. In fact, this first successful airplane weighed about 800 pounds.

This was really a remarkable event! Here was something that was very heavy and yet it could move through the air. This seemed very difficult to understand. After all, people had long observed that anything heavy would fall to the ground unless supported; that is, anything except birds. However, birds weigh much less than 800 pounds.

Some of our present-day airliners weigh about 130,000 pounds. How are they able to lift such a tremendous weight? Why don't they fall to the ground?





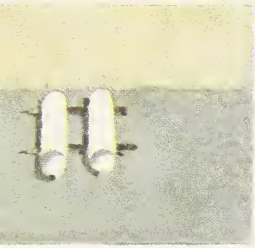
Air over the Wing

It is the wings of airplanes which make flying, as we know it, possible. Notice the shape of an airplane wing. The front, or leading, edge of the wing is thicker than its trailing edge. The top of the wing is curved, but the underside is almost flat. Each wing is attached to the fuselage in such a way that it tilts slightly, just as you see in the pictures on this page.

Air presses on all parts of the plane and wings. As the plane moves through the air, the curved edge of the wing slices the air. Some of the air flows over the wing. Another stream of air moves under the wing. We are told that both streams of air reach the back edge of the wing at the same time.

Look at the drawings on this page of an airplane wing. You can see that the distance over the top of the wing is greater than the distance under the wing.

The stream of air that goes over the top of the wing has farther to travel than the stream that goes below the wing. If both streams of air reach the trailing edge at the same time, the air over the top of the wing must travel faster than the stream of air passing under the wing.

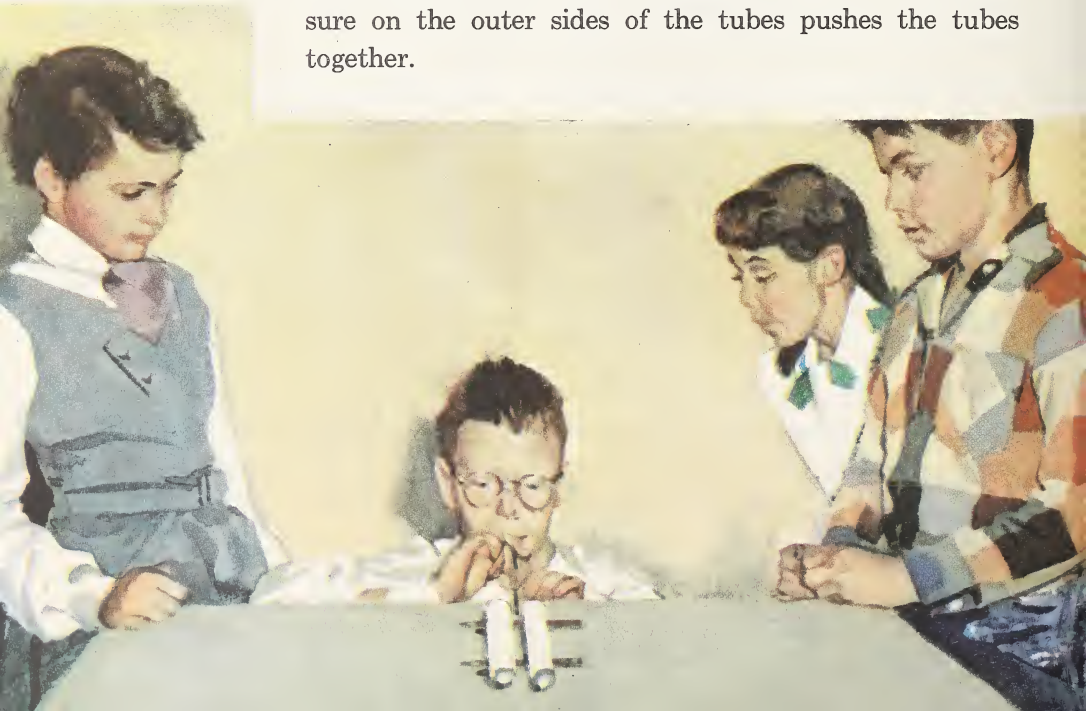


Air Loses Pressure

The stream of air that moves over an airplane wing loses some of its push, or pressure. This loss of push is brought about as the air begins to move faster.

To help you understand that faster-moving air has less pressure, you might do an experiment. You will need two pieces of paper each about 6 inches square, two pencils, and a soda straw. Paste the opposite edges of each square of paper together so that each will form a hollow tube. Lay the pencils on the desk about 3 inches apart. Place the paper tubes across the pencils about 1 inch apart, as you see in the picture at the left. Take the soda straw and blow between the two tubes. The two paper tubes roll together!

When you blow through the straw, the air moves rapidly between the paper tubes. The fast-moving air between the tubes has less pressure than the air on the outer sides of the tubes. The greater amount of air pressure on the outer sides of the tubes pushes the tubes together.



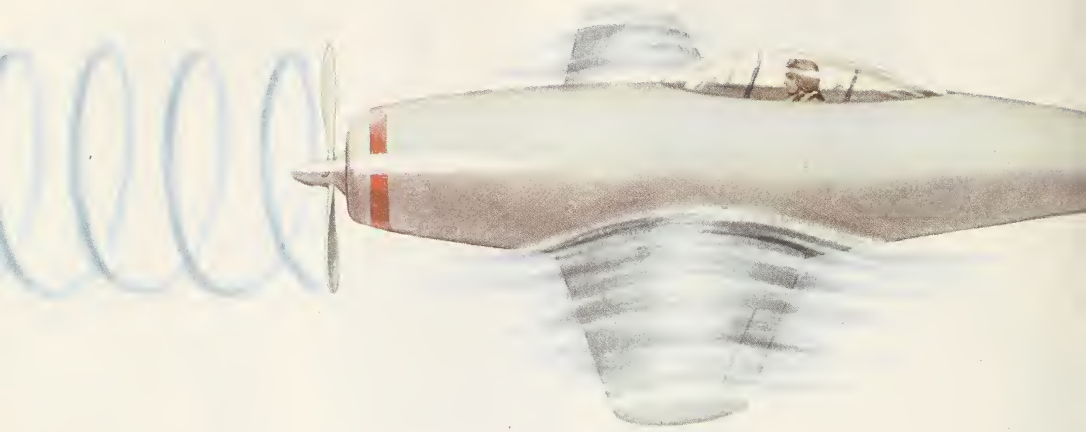
Air moves very fast over the top of an airplane wing. It moves under the wing more slowly. The air below the wing has more pressure than the faster-traveling air above. More pressure under the wing pushes the wing upward. When this happens, the wing lifts. We say that the force of lift helps to keep the plane in the air.

You might make a paper wing which will show how moving air helps to lift an airplane. Cut out a piece of paper about 2 inches wide and 6 inches long. Attach the paper to a wooden stand, just as you see in the picture. Notice that the unattached end of the paper wing will fall toward the ground.

Now blow across the top edge of the paper wing. Blow hard! Do you see how the wing rises? The faster you get the air going over the top of the wing, the more the wing will rise.

Vary the way you blow air over the wing. Blow hard, then blow more gently, and then increase your blowing again. As you do this, the wing will rise, go down, and then rise again.

You are really changing the air speed over the top of the wing. As you increase the air speed, the pressure on top of the wing is lowered. The greater pressure on the bottom of the wing pushes it up.



The Propeller

Of course an airplane does not only lift, but also moves forward. You might say that a plane is pulled forward through the air by its propellers. In fact, a propeller could be thought of as working much like a screw. Have you ever put a screw into a piece of wood with a screwdriver? As the screw turns, it is forced into the wood. The faster you turn the screw, the faster the screw goes into the wood.

Now think of an airplane. An engine of a plane turns its propeller much as a screw is turned. The blades of a propeller are twisted. The twisted blades slice through the air and force air toward the back of the plane. As the air moves backward, the plane moves forward. The faster the propeller spins, the faster it pulls the plane through the air.

The propeller has to turn rapidly and pull the plane forward along the ground before the wings lift. As the plane moves, much air passes over and under the wings. The faster the plane moves along the ground, the faster the air moves over the wings. When there is enough difference in the pressure of the air above and below the wings, the plane will rise.

So you see it is necessary for the plane to move forward on the ground before air moves fast enough over the wings to provide lift for the plane.

The force which moves the plane forward is called thrust. We have seen how thrust is created by a propeller turned by an engine. Let's see another way in which an aircraft can be thrust, or sent forward, through the air.

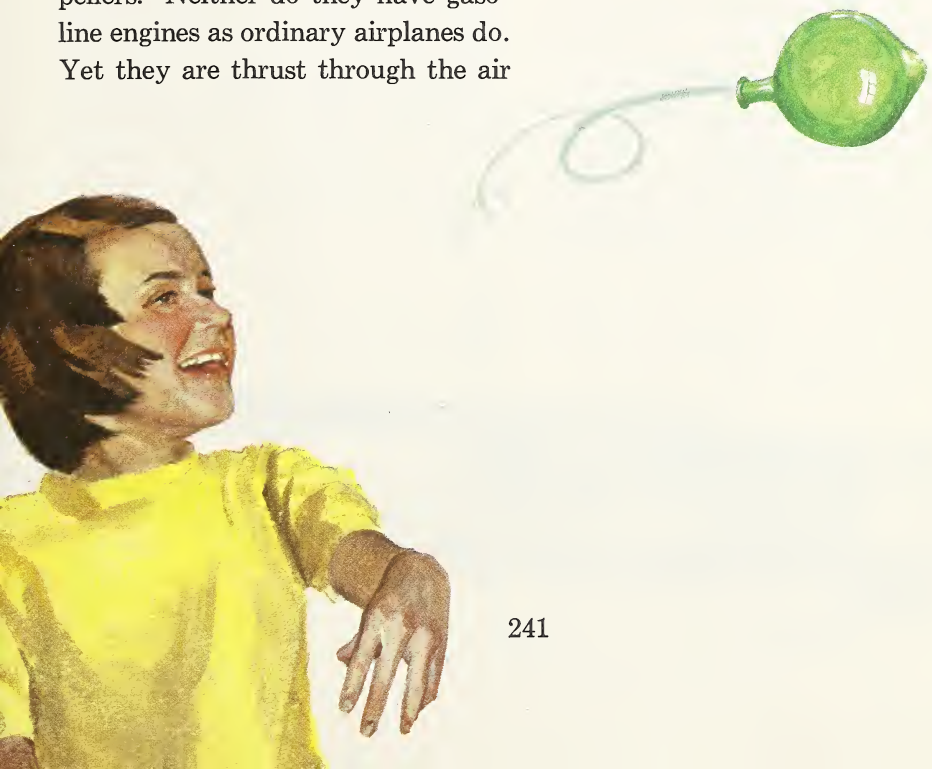
Jet Planes

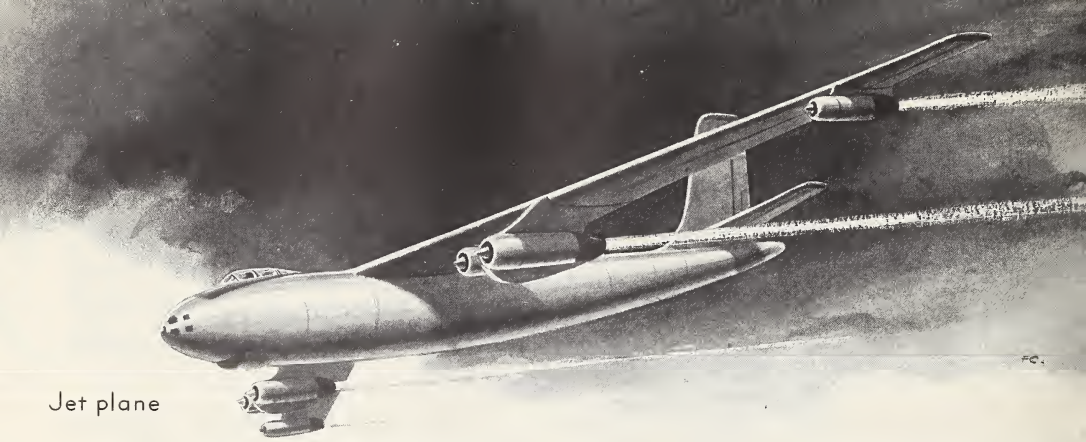
Perhaps you have heard the sound of a plane roaring overhead. When you looked up to see it, it was gone. You may have seen only some trails of vapor left behind. The plane you heard was probably a jet plane.

Many jet planes do not have propellers. Neither do they have gasoline engines as ordinary airplanes do. Yet they are thrust through the air at great speeds. Such planes receive their thrust from jet engines.

You can make something which resembles a jet engine by using a balloon. Blow air into the balloon. Then without fastening the balloon, throw it into the air. It will whirl around the room in jet-propelled flight.

A blast of air comes out through the opening in the balloon. This air pushes the balloon along. As the air rushes out from the neck of the balloon, there is a push in the opposite direction. As long as the air rushes



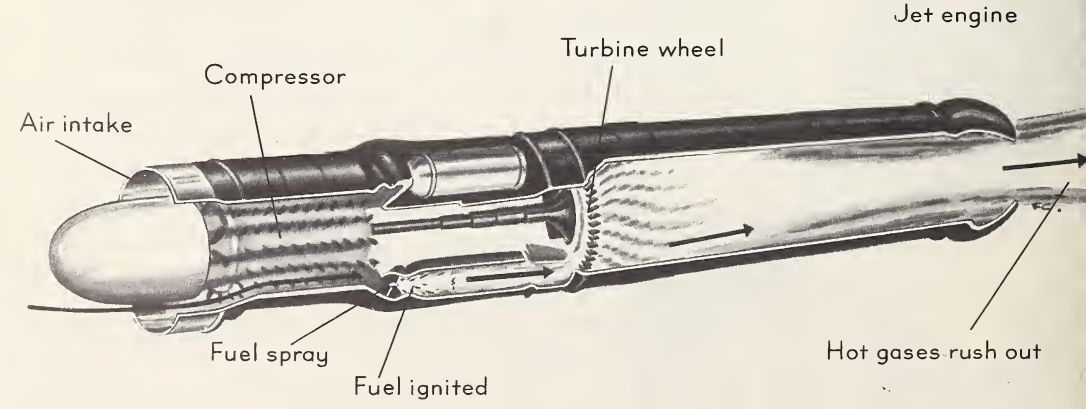


Jet plane

out of the balloon, the balloon keeps on moving through the air. Air rushes out in one direction, and the balloon moves in the opposite direction.

A jet engine pushes a plane forward in much the same way as the balloon was moved through the air. To get this thrust, a jet engine uses air from the atmosphere. The air is taken into the engine and is pressed into a small space, or compressed. Then some fuel, usually kerosene, is pumped into the compressed air. As the fuel burns, the hot gases expand very rapidly. They rush out through an opening at the back of the engine. This pushes the jet plane forward.

The hot gases provide thrust for a jet plane, just as the escaping air did for the balloon. They push a jet plane through the air at terrific speeds.



Some jet planes have traveled faster than sound. We usually say that sound travels about 760 miles an hour. Certain types of planes have traveled more than 1300 miles per hour.

Just think! At that speed it would take a little less than two hours to go from one coast of the United States to the other. You could leave New York at 8 A.M. one morning and arrive in San Francisco about 7 A.M. the same morning. Because of the difference in time between the two cities, you would arrive in San Francisco at an earlier hour than that at which you left New York.

Gravity and Drag

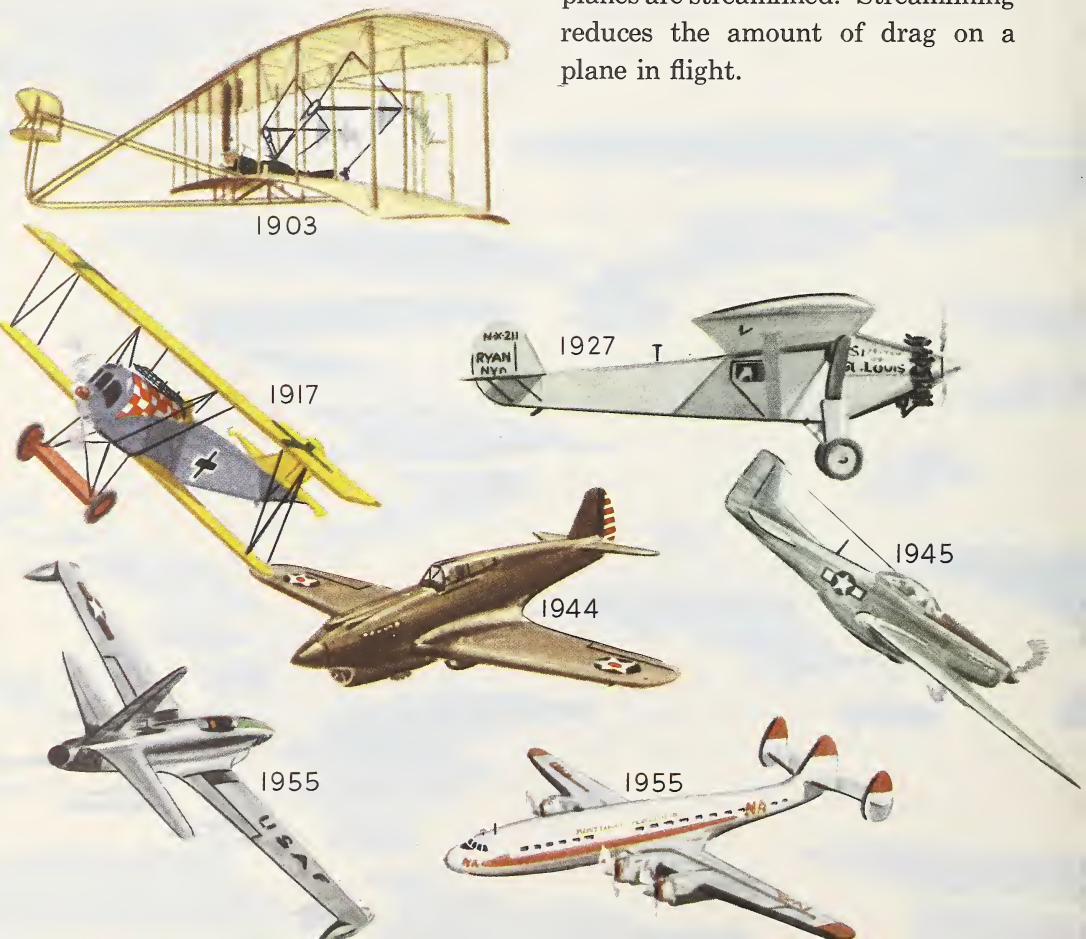
Another very important force that acts on a plane in flight is gravity. Gravity is the force which pulls everything toward the earth. Before man could fly in a plane that was heavier than air, he had to design a wing that would overcome the pull of gravity. The wings of a plane provide its lift.

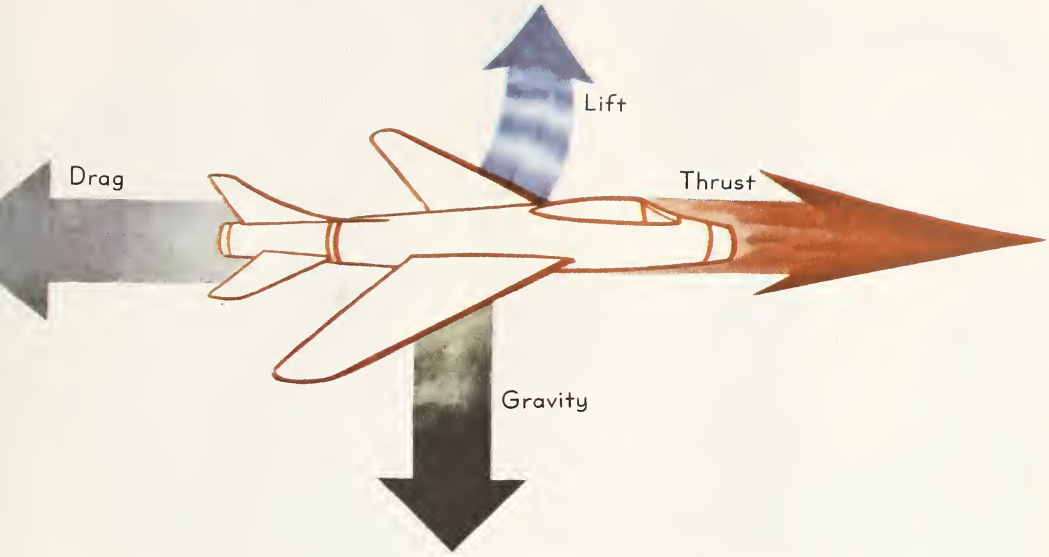
In order to stay in the air, a plane must be thrust forward. As long as it moves fast enough through the air so that the force of lift is stronger than the force of gravity, a plane

will fly. Whenever the force of lift becomes less than the force of gravity, a plane will sink to the earth.

As a plane moves forward, air rubs against the wings, the body, and other parts of the plane. There is friction between the air and all parts of a plane. The force of this friction is called drag. The more drag, the harder it is to thrust a plane through the air. For a plane to move forward in flight, the force of drag must be less than thrust.

There are some parts of the plane that do not help to lift or pull the plane. Today these parts are designed to lessen the amount of drag. Look at the different planes in the pictures below. These are some of the first planes and some that we use today. You can see that present-day planes are streamlined. Streamlining reduces the amount of drag on a plane in flight.





Four Forces

Look at the drawing of a plane on this page. It shows the four forces which act on a plane when it is flying. They are thrust and lift, drag and gravity. Thrust and lift must be stronger than the forces of drag and gravity if the plane is to fly.

Every plane has a slow-flying speed at which it can continue to move through the air. If a plane moves slower than this flying speed, the forces of drag and gravity become greater than the forces of thrust and lift. When this happens, the plane may begin to drop downward toward the earth. A crash may occur if the plane does not regain its flying speed.

Careful balancing between these four forces provides the way to control the flight of a plane. As a plane is landing, a very delicate balance is maintained between these forces. The flying speed is continually decreased as the plane comes in for the landing. When the wheels are about to touch the runway, the pilot points the nose of the plane up slightly. This increases wind resistance and slows the plane still more. With the help of the forces of gravity and drag he is able to settle the plane gently on the runway. The plane is no longer flying as it moves along the runway. It has landed.

Airways from Here to There

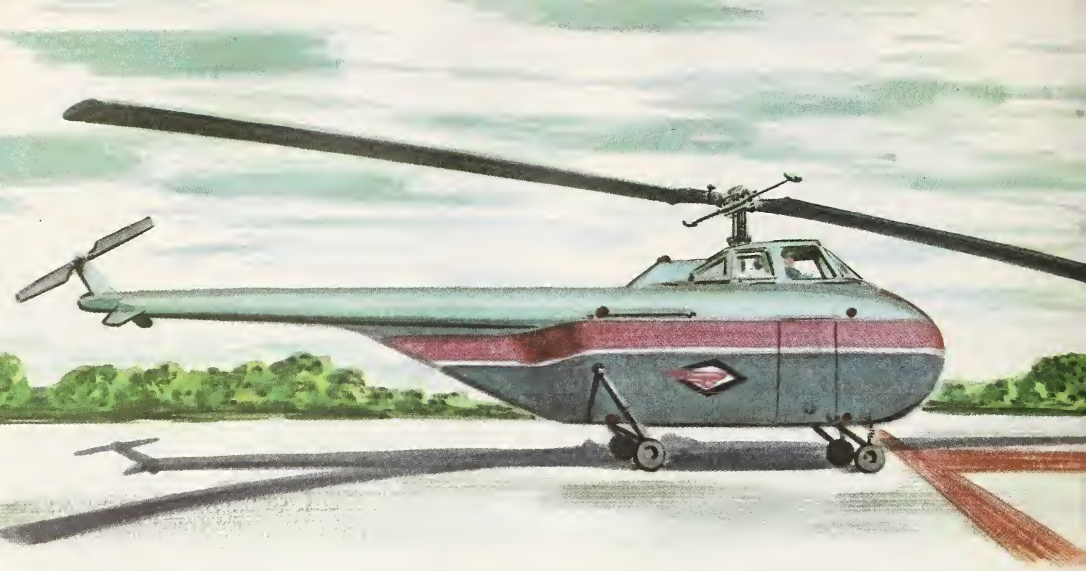
Look at the map on this page. It shows some of the routes that planes travel. You will notice that each airway is marked with a certain number of hours. This indicates the time it takes the large passenger planes to travel between the two cities connected by the airway. Find the airway between Chicago and Los Angeles. You will see that the trip takes about six hours. Of course the flying time on any of these airways depends on the speed at which the plane can be flown. The passenger planes used by the airlines are always being improved. So you will probably find that the flying time on many of these airways will change.

In the United States and Canada there are many regular commercial air flights each day. There is an airport within a few miles of almost every large city. From north to south, east to west, the airways link our cities.

The map above is a global map. You will see that the air miles between some of the cities have been marked. Over thousands of miles of airways, we can fly a plane to any part of our earth.

Imagine that you are piloting a plane from Los Angeles to Copenhagen. Suppose your plane could fly at a speed of 1000 miles an hour. How many hours might it take you to reach Copenhagen?

As flying speeds increase, it takes less time to travel between these cities, even though the distance remains the same. We might say that the faster our planes are able to travel, the smaller the earth becomes.



Helicopters Have Moving Wings

Most of the aircraft that we are familiar with have wings attached to the body of the plane. You might say that the wings are fixed. They don't rotate or move along or around the plane.

The aircraft on this page is called a helicopter. Look at the blades above the body of the helicopter. They turn round and round. They are really movable or rotating wings.

The rotating wings give to the helicopter special qualities. You have probably seen a helicopter hovering above one spot. It looks as though it were suspended in the air! The air moving over the rotating wings of the helicopter provides enough lift to just overcome gravity. The aircraft neither falls nor rises. It remains suspended!

The pilot of a helicopter can move it forward and backward and sideways by regulating the moving wings. The helicopter can also be moved up and down somewhat like an elevator.

We usually call a specially prepared area where airplanes take off and land an airport. But have you ever heard the word *heliport?* A specially prepared area from which helicopters take off and land is often called a heliport.

Heliports are much cheaper and easier to build than airports. A heliport also requires much less space. It can very easily be located on the roof of certain types of buildings.

Helicopters are of use in many different ways. Again and again they have proved their value in emergency rescue work. They also have many day-to-day uses. For instance, in Los Angeles, California, helicopters are being used in the mail service. During the day there are flights by helicopter from the main post office to the airport. The Los Angeles post office is located in the business district. The helicopters take off and land on the roof of the post-office building.

Helicopters are also used to pick up and deliver mail to communities around Los Angeles. Some of these communities are as much as 50 miles away. Much time is saved by using this helicopter service.

This same type of mail service is used in Chicago and New York. In New York the helicopter service carries passengers as well. Passengers are carried between major airports in and around New York. There is helicopter service between Newark airport in New Jersey and Idlewild and La Guardia airports in New York.

Helicopters are also being used to carry passengers and mail between large cities in Europe. In the future much of the travel between nearby cities and towns may be done by helicopter. There may be a heliport in every town!

Independence Pass

Into Space—Beyond Our Earth

Zoom into outer space! Off to the moon!

This is easy to say, but what about actually doing it? There will be many problems to be solved as man attempts to go into outer space beyond our earth.

Up and Up

At just a few thousand feet above sea level we may encounter some of the same difficulties that we would face in outer space. The higher we go, the less oxygen there is in the air. Our bodies need a certain amount of oxygen if we are to remain healthy and active. At high altitudes there is so little oxygen in the air that it becomes difficult to breathe. We do not have to go into outer space to run into difficulties of this sort.

Many people become dizzy and short of breath when they are at heights of about 11,000 feet or more. This can happen in many places right here on earth.

The high point at Independence Pass, near Aspen, Colorado, is about 13,000 feet above sea level. At this spot even mild exercise, such as walking or running, may make a person feel ill. This illness is caused by lack of oxygen. It is called altitude-sickness.

Some people can get along fairly well on the oxygen that is in the air up to a height of 20,000 feet. Explorers have even been able to climb to altitudes as high as 26,000 feet. As we go to higher and higher altitudes, there is less and less oxygen.

Many planes fly at heights above 20,000 feet. Some of the larger passenger planes on long runs make regular flights at altitudes of 38,000 feet. In order for passengers to live at this height, special equipment is needed. In all planes that fly at such heights there is a way of supplying oxygen to the passengers and crew. We say that these planes are pressurized.

Men and women in the Air Force use oxygen equipment much like that which you see in the pictures on this page. They use this equipment when flying at altitudes above 10,000 feet. Then they will surely have enough oxygen to breathe.

Man Out in Space

Man does not have to go very far from the surface of the earth before he is out in space. Maybe you have never thought of it in this way.

You might say that man is out in space when he has reached a height at which there is not enough oxygen for him to breathe. At altitudes above 50,000 feet man cannot get enough oxygen from the air to keep himself alive. At these heights he would die in about 15 seconds if he did not have special oxygen equipment.

Fifty thousand feet is not very high. It is only about 10 miles above sea level. But when we get to this height we are no longer in the kind of atmosphere in which we can live. For all practical purposes, we are out in space!

As we go into outer space, we must make sure that it is possible to remain alive. If this cannot be done, travel into outer space will not be practical. So for man himself the crossing of the 10-mile limit is the first important step into outer space.

Pilots who fly in aircraft above the 10-mile limit wear special flying suits. In the picture on this page you can see a pilot prepared for flying at high altitudes. His suit is airtight. You might say that he carries his own atmosphere with him. Inside the suit there is enough oxygen for him to breathe. The part of the suit next to his body remains at a temperature which keeps the pilot comfortable.

Many things have already been done to overcome this problem of keeping man alive in outer space, but there is still a great deal that has to be found out.

Oxygen for Engines

As we go farther and farther from the earth's surface, the decrease in oxygen in the atmosphere makes traveling difficult. Not only do we need oxygen to breathe, but the engines that push our aircraft through space need oxygen also.

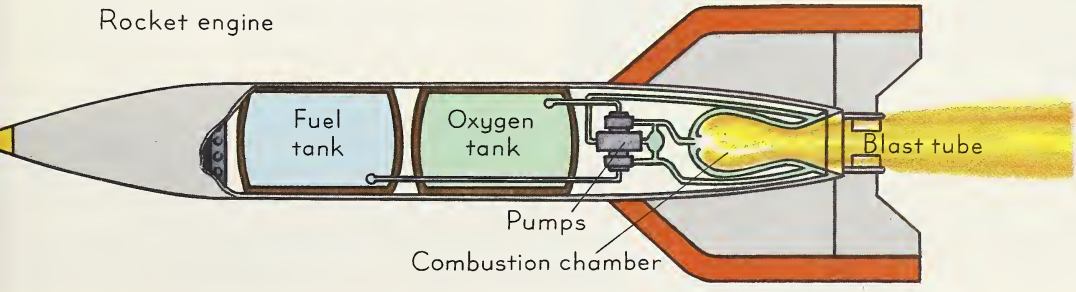
Douglas Skyrocket

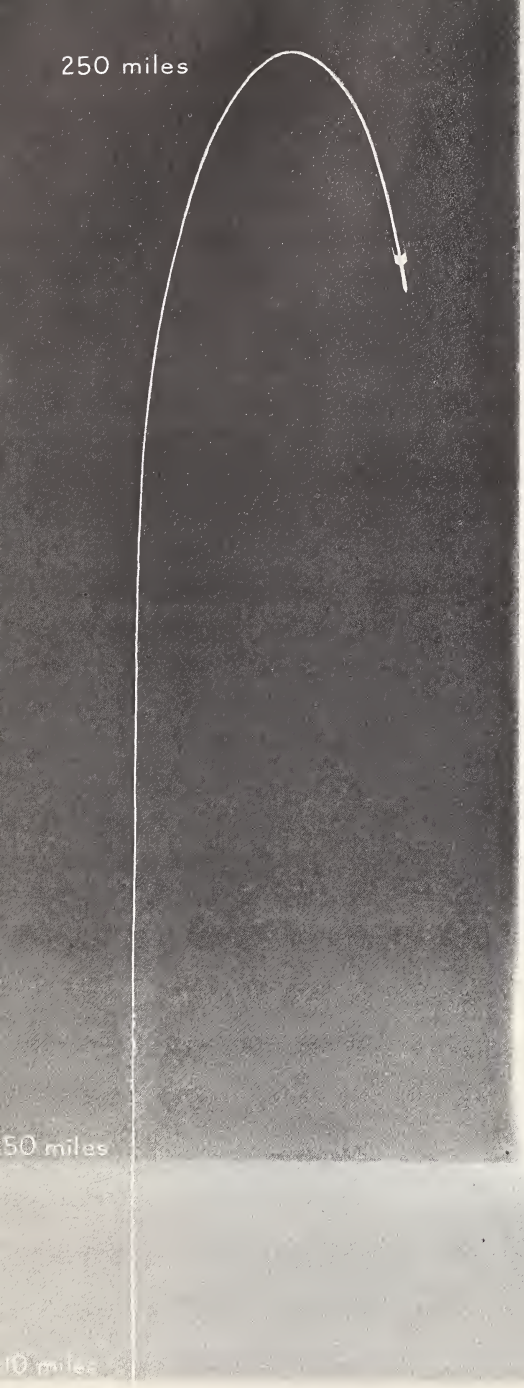
Many planes have gasoline engines. These engines must have oxygen so that the fuel will burn and supply the energy which powers the plane. Jet engines also use oxygen to burn their fuel. Difficulties arise as these planes go farther and farther from the earth's surface. It has been found that at high altitudes there is not enough oxygen in the atmosphere for the fuel to burn.

Both the gasoline engine and the jet engine will stop operating at high altitudes. At heights of only 70,000 feet, or about 13 miles, neither of these engines operates well.

As man goes beyond this altitude, other types of engines must be used to supply the power needed to keep the aircraft moving through space. Rocket engines have been developed, which carry their own oxygen supply. They do not depend upon the oxygen in the atmosphere. A rocket-powered aircraft called the Douglas Skyrocket has reached an altitude of 15 miles. Even as you read this, other planes are probably going higher. Each day brings new advances in our aircraft.

Rockets without pilots have risen to altitudes as high as 250 miles.





However, these rocket engines used all their fuel to get to this height. Without fuel the engines were not able to produce energy to keep the rockets moving through space. Powerless—they fell back to earth.

Problems and More Problems

The peak of Mount Everest is the highest land surface on the earth. It is about 29,000 feet, or nearly 6 miles, above sea level. This seems a great height until we think that rockets have risen to altitudes over forty times as high. Yet even 250 miles is not very far in comparison with the great distances in outer space. Our nearest neighbor, the moon, is about 240,000 miles from the earth. To reach the moon, we shall have to fly our rockets about a thousand times as far as any have yet flown. We have not yet been able to get very close to the moon, have we?

Many important steps have been taken in space travel. However, there are still problems which must

be met before travel in outer space will really be successful.

Men and women interested in space travel are at work developing new fuels to give greater power to rockets. This is a very important problem. At heights of 60 to 70 miles space ships will not receive much lifting support from the atmosphere. The power of the rocket engine will be the space ship's only source of lift and push.

Heat will also be a real problem in space travel. Space craft will become very hot if they move at tremendous speeds. Heat from the sun will be an additional problem as man moves farther and farther out into the darkness of space.

There will probably be many other problems which will arise with each new step. No one can tell what all the problems will be. How they will be met and solved depends on how wise and intelligent we are. There are many things to be done. A whole new world may await us as we attempt greater and greater journeys into space. No one knows. But this we do know—we are on our way!

LEARNING MORE ABOUT FLIGHT

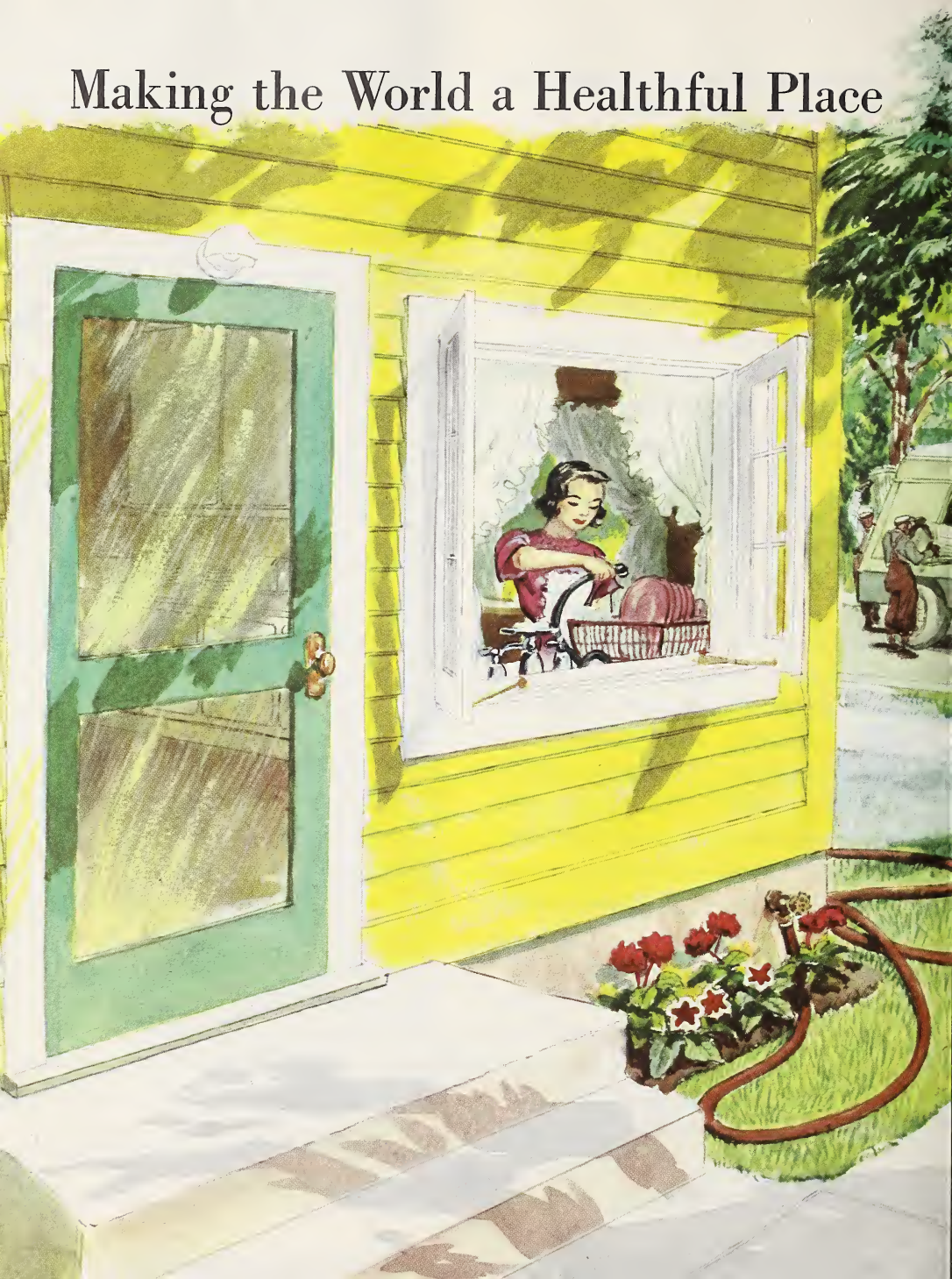
1. Many people have helped aviation develop. Maybe you know about Charles Lindbergh, Amelia Earhart, Wiley Post, Jimmy Doolittle, and Eddie Rickenbacker. You might be interested in reading about the important work done by these people.

2. There are a great many airports throughout our country. You might plan to visit an airport near your town. One of the places you should get permission to visit is the traffic-control tower.

3. We are told that many changes in living have taken place because of the airplane. How do you think the airplane has affected your life? In what ways would our world be different if there were no airplanes?

4. Many boys and girls have learned a lot about airplanes and flying by building model airplanes. There are many types of model airplanes that you might build. Some boys and girls build and fly models which have engines. It is a very interesting hobby.

Making the World a Healthful Place

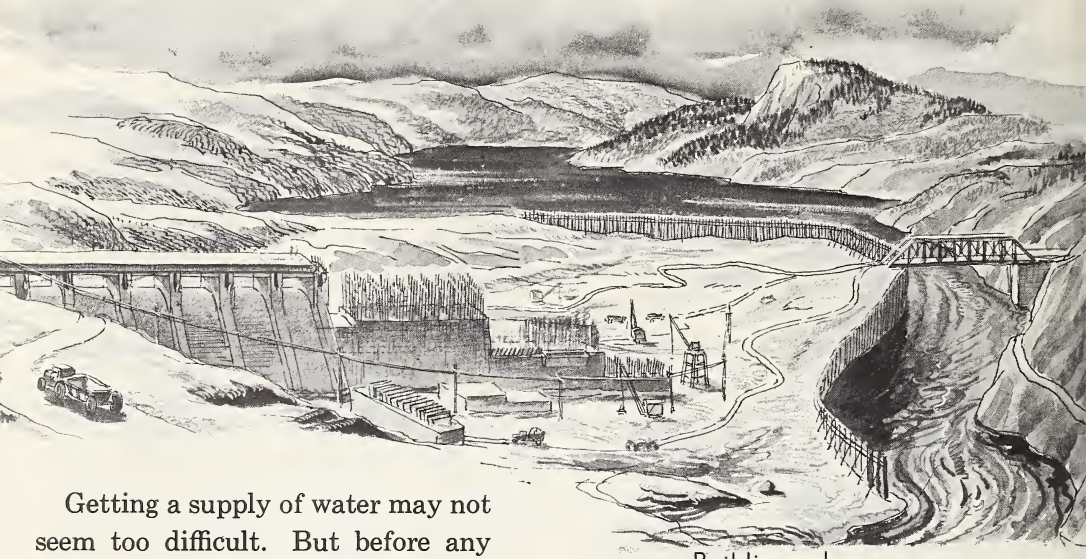


The Community Around You

All you may need to do to obtain water to wash your face in the morning is to turn a faucet. When you have finished washing, the soapy water runs down the drain. It runs through pipes out of your house and maybe even out of your community. Perhaps you have never stopped to think where the water comes from and where it is going.

When you have finished eating your breakfast, there may be some scraps of food remaining. Perhaps there are some orange peels or an eggshell. These food scraps are probably put in the garbage can. You may have seen a truck come to your home to collect garbage, but what then? Where is the garbage taken in your community and how is it disposed of?

Perhaps you live in a large city. One of the biggest problems facing any large community is where and how to obtain a good supply of water. You and everyone else in your city must have water for drinking, bathing, cooking, and many other purposes.



Building a dam

Getting a supply of water may not seem too difficult. But before any water can reach a city home, many plans must be made. A source of water must be found large enough so that everyone in the city can have enough water to use. It is also important that the water should be clean and pure. When you turn a faucet in your home and are supplied with pure water, you know that your city has solved this problem.

The drains which carry away water after you have used it are another way in which your community is meeting a health problem. How to dispose of garbage and other waste materials are still other problems which a city must solve. Yes, much must be done in a large community to make it pleasant and healthful.

Perhaps you live in a small community or even on a farm. Here the problems of a pure water supply and of disposing of waste materials may not be faced by the community as a whole. Each householder may have to find his own solution.

Often we are not aware of the many things necessary to our community's health. Communities are not all alike and their answers to their problems are different also. There are several possible solutions and some are better than others. When a community is clean and pleasant and healthy, it usually means that its problems have been intelligently solved.

The Water You Drink

"Rain, rain, go away!" But if the rain goes, we shall have less water to use. During times of little rainfall we are sure to hear talk about our water supplies.

All our water supplies are the result of rain, snow, sleet, or hail. Much of the water that falls from the skies moves along the surface of the ground. It may flow into creeks and rivers. It may even collect in bodies of water such as ponds and lakes. This water which moves along or collects on the surface of the land is called surface water. It is a source of water easily available to us. But surface water is easily polluted. We have to be very cautious about using surface water.

Some of the water which falls on the land sinks into the soil. Here part of it may be used by plants. As water moves down into the soil, it may collect below the surface of the ground. This water stored in the soil and in certain layers of rock below the surface is called ground water. Sometimes ground water moves through the ground and reappears on the surface as a spring.

Ground water may be made available for use if wells are dug or drilled. As water is drawn from underground sources, the supply is gradually lowered. But all the while, water falling on the surface of the earth moves down through the soil or rock to add to the supplies underground. We must take care that we do not use our supplies of water faster than they can be refilled. We are always looking for better ways of collecting and storing the water which falls on the earth.

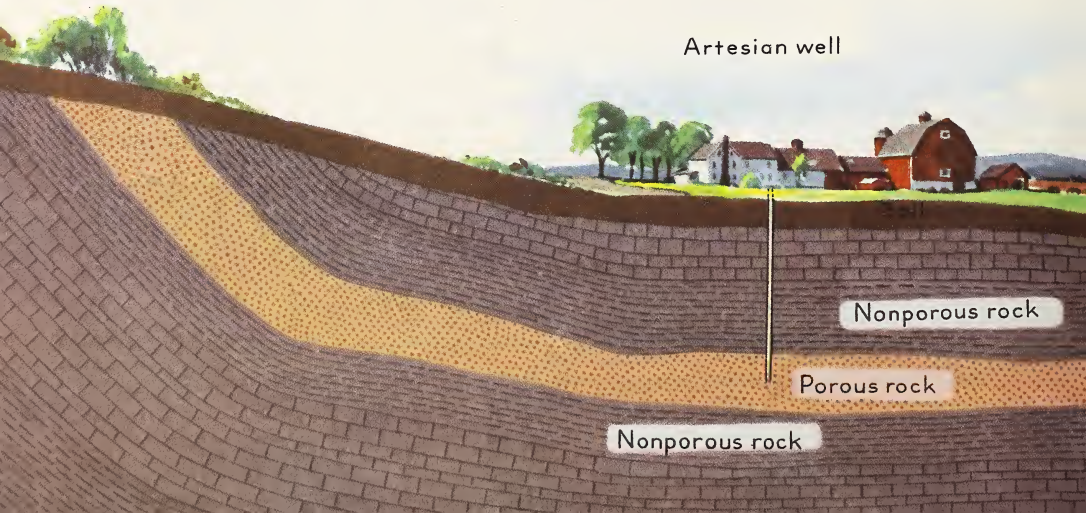
Artesian Wells

Perhaps you live in a town or a city which gets its water supply from a river, a mountain stream, or a lake nearby. Or the city you live in may bring its water by pipes from a reservoir built many hundreds of miles away. Instead of using surface water, some cities draw their water supplies from underground. The wells from which much of this water comes are called artesian wells.

Many country homes too obtain their water from these sources. Water from artesian wells will usually flow to the surface without the need of pumping. These wells yield a supply of water which is much purer than most surface water. However, the presence of an artesian water supply in any region depends upon very special rock conditions.

To have an artesian water supply, there must be three separate layers of rock below the surface of the soil. The middle layer must be a kind of rock that has many tiny spaces in it. Rock of this sort is said to be porous. Water will move easily through porous rock. Above and below the porous layer there must be layers of nonporous rock. These keep the water trapped in the porous layer.

There is another condition to be met if the porous layer is to be an artesian supply. In the picture below, do you see how the layers of rock are tilted? At its upper end the porous rock is exposed. It is able to soak up rain and melting snow. The force of gravity moves the water through the tilted porous layer. Artesian wells may be drilled to the porous layer at some point



below the exposed end. There will be enough pressure to bring the water to the surface.

Sometimes artesian wells are thousands of feet deep. In many dry regions of the earth artesian water is the only source available for irrigation. Parts of the Sahara Desert have been made to bloom because of water from artesian wells. It seems hard to believe that below such a sandy, hot desert as the Sahara there is water—water trapped in porous rock. It is there for the taking. With it man can turn the desert into a productive garden.

Here is something you might do which will help you to see how water rises in an artesian well: You will need a large tin can, a piece of rubber tubing about 3 feet long, and some bricks. First, make a hole in the bottom of the tin can and insert one end of the tube in the hole. Close the other end of the tube with a cork or some clay. Clay or plasticine may also be used to seal the fitting between the tube and tin can. The tin can should then be placed on a hollow platform made of bricks, as you see in the picture.

Now when water is poured into the tin can, it will flow from the can into the rubber tube. But the water does not flow away. It is trapped in the tube. Do you see that the tube is somewhat like an artesian water supply? The tube takes in water at its upper end like the porous rock layer. The water is trapped in the tube as it is in the rock.

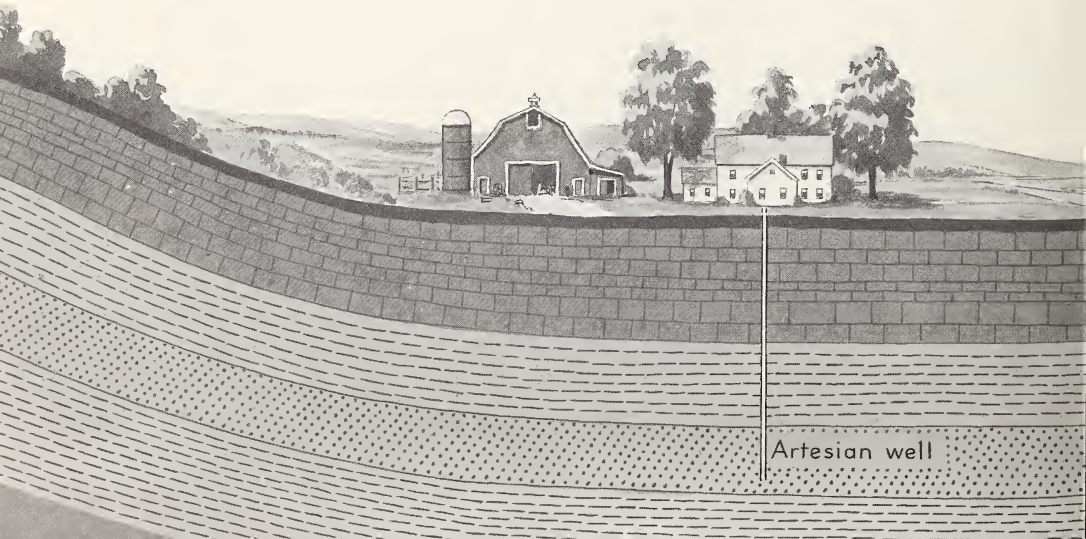
All that remains for you to do is to sink a well into the "porous rock layer." First, fill the tin can with

water. You can sink your well by making a hole in the tube with a sharp, large-sized carpet tack. Notice that once the hole is made, the water spurts into the air. How high does your water column rise?

An artesian system is like a huge underground reservoir. The arrangement of the three layers of rock makes it possible to have a continuous supply of water. The water enters an artesian system through the exposed porous layer. But care must be taken in how the water is withdrawn. We must balance what we take out by what has gone into the reservoir.

Such rock structures may be found in many regions of North America. Of course the porous layers are at different depths throughout these regions. And they include different kinds of porous rock. For instance, a rock called Dakota sandstone forms the porous layer beneath one large area of North America. Water enters this porous sandstone near the base of the Black Hills in South Dakota and along the eastern foothills of the Rocky Mountains. It moves far below the surface of the soil through parts of Nebraska, South Dakota, Colorado, and Kansas.

In many areas of North America the amount of water drawn from the underground reservoirs has been greater than the amount entering. Water no longer comes to the surface under its own pressure in these areas. This is a great loss to everyone in the region.



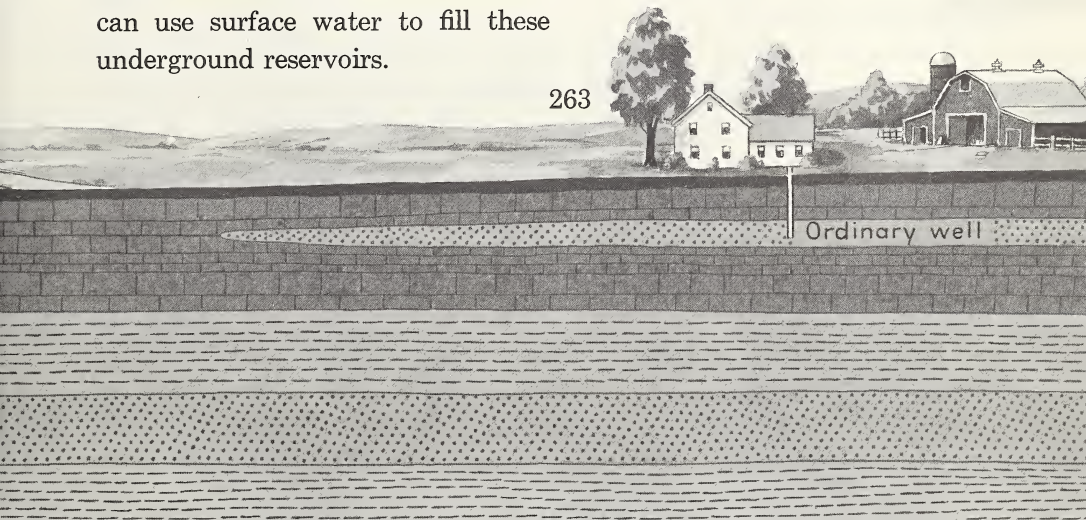
Many states and provinces are trying to protect and redevelop their artesian water supplies. There are laws to prevent waste of the water from artesian wells. Engineers from conservation departments work with owners of artesian wells to get the best possible use of water and pressure. Valves are used to help control the flow of water. All unused wells and those which leak are carefully sealed. This helps to eliminate waste. It also does much to increase the water level and pressure in the other artesian wells in the region.

Our underground reservoirs may become one of our most important sources of water. The rock layers are there! You might say that the reservoirs are built. All we have to do is to keep them filled with water. Rainfall and snowfall will help. But there is also the possibility that we can use surface water to fill these underground reservoirs.

One thing is certain: water and water sources are important to our growing country. How shall we make the best use of the rock structures that make artesian water supplies possible?

Safe Water in the Country

Perhaps you live in a small village or on a farm. The water you use may come from an artesian well. Or it may come from an "ordinary" well that has been dug in your yard. In that case the water that you drink is ground water. If you have an artesian well, your water may come from rain or snow which fell on the earth many hundreds of miles away. An ordinary well, however, is more dependent on the amount of rainfall



nearby. It must draw its supply from the water that has soaked down into the ground from the surface of the surrounding soil.

In some places an ordinary well may be dug 125 feet deep before water is reached. In other places the well may have to be dug much deeper. The level of ground water is not the same in all parts of the earth. The sides of the well are lined with brick and concrete or material that is called casing. The top of the well should have a metal covering over it. This will help to keep well water safe for drinking.

People who use water from their own wells should have the water tested from time to time. This can be done by asking someone from the Board of Health to come and test the water. It is also possible to send a sample of well water to the Board of Health for testing. Perhaps you have hiked or camped near a spring or stream. You may have noticed a sign posted nearby telling whether the water was safe to drink. Such a sign was probably posted by the Board of Health.

Sometimes water from a barnyard or an outdoor toilet or cesspool may seep through the ground. Harmful bacteria may get into the ground water. Then the well water which is drawn from this polluted ground water will also be polluted. To prevent this, it is wise to locate ordinary wells on high ground. Do you think that this is true of artesian wells also?

Making Water Pure

No matter where it comes from, you enjoy drinking water that is clear, colorless, and has a good taste. You also want to know that it is free from bacteria and other materials that may cause disease. These materials found in water are called impurities. To make water safe and pleasant to drink, impurities must be removed.

Look at the picture below. It shows the way one city purifies the water it uses. Rain and water from melting snow run off the watershed areas into a large reservoir. Then the water flows through pipes to another reservoir. This place is called the settling basin. The water stays here for several days. During this time soil or other solid particles which may be in the water will settle to the bottom.

After the water leaves the settling basin, it flows into what is called the filter bed. There is a layer of gravel at the bottom of this bed. On top of the gravel is a layer of coarse sand, and above this a layer of fine sand.

When the water enters the filter bed, it begins to move down through the three layers. First, it moves slowly through the fine sand. The sand catches many particles of soil and tiny plant and animal life. We usually say that the water is filtering through the sand.

Then the water flows down through the coarse layer of sand, and finally through the gravel. In the layer of gravel there are many pipes. The

pipes are made of porous material, which allows water to go through it. The material is much like that used in flower pots.

You might try an experiment to see how water can pass through porous material. First, use a can opener to cut a round hole in the bottom of a tin can. Then force a small flower pot down into the opening so that it is held in the hole, just as you see in the picture. Seal the edge between flower pot and tin can with clay or plasticine to make it watertight. Now pour water into the can so that the flower pot is surrounded by water. In a short time water will begin to seep through the walls into the flower pot.

The pipes set in gravel in a filter bed work in much the same way. Water seeps from the gravel through the porous pipes. From these pipes the water flows into larger pipes. Finally, the water is carried to the homes and buildings in the city.

To make sure that drinking water is safe, a chemical called chlorine is usually added to the water after it is filtered. In very small amounts it is not harmful to the human body. But the chlorine does kill harmful bacteria.

Of course, not all cities and towns purify their water by filtering it. But most communities add chlorine or some other chemical to water to make it safe for drinking. If you live in a city or town, find out how your community purifies the water you drink.

Where Do the Drain Pipes Lead?

"Going swimming in the bay?" That is the question your father could have answered with a "yes" if he lived in a certain east coast city when he was a boy. But the boys and girls who grew up there during the 1940's and 1950's have never been allowed to go swimming in the bay. The water surrounding the city is not safe!

During the early 1900's this city was a resort area. People came from miles around to swim in the surrounding waters. Then many industries moved to the city because there were good port and shipping facilities. The population increased and the city changed from a resort to an industrial center.

The wastes from industries and from private homes were carried by pipes to the water of the bay. Gradually over the years the water became polluted. There was so much waste material in the bay that at times it colored the water. Much of the animal and plant life of the bay was destroyed. The water was no longer a safe place in which to swim.

The people in the city did something about this condition. If the water was to become clean and productive again, the waste would have to be disposed of in some other way. In 1953 this city began building a large sewage-disposal plant. In time, if all goes well, the water may be safe enough to swim in again.

In Large Communities

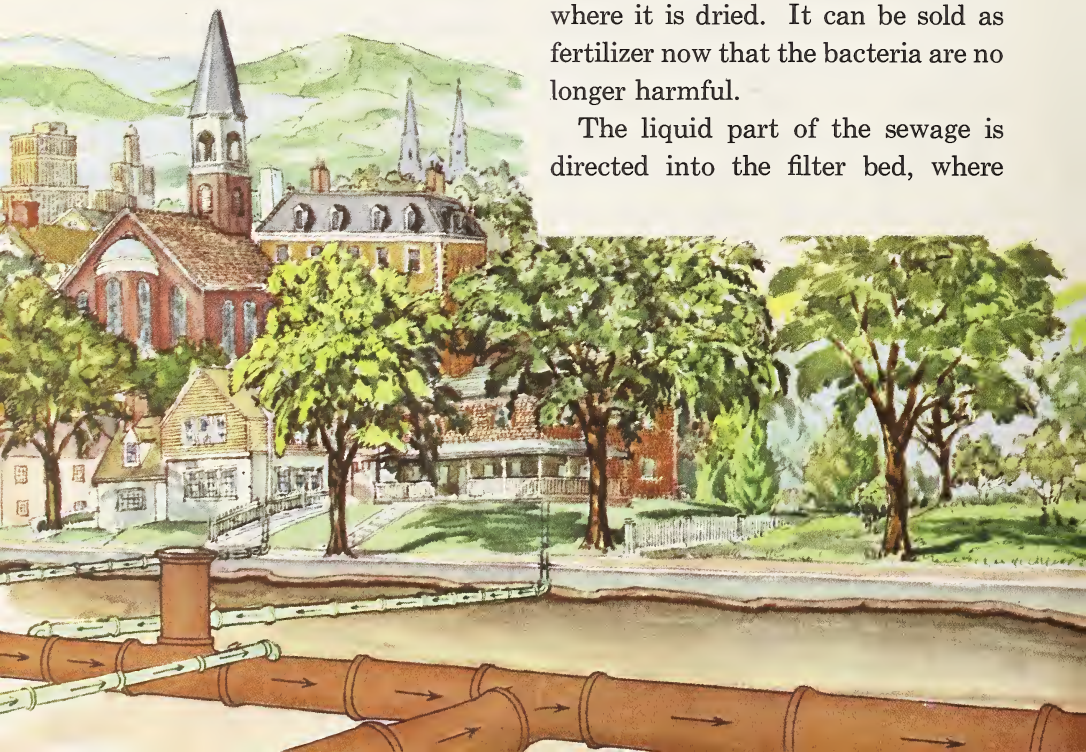
Sewage flows into rivers, lakes, and coastal waters from other cities and towns, also. When this happens, of course the water becomes polluted. It is not a pleasant thought, is it?

Some communities are correcting these mistakes. The picture below shows you how sewage is disposed of in one city. All the drain pipes in the city lead to a sewage-disposal plant where the sewage is treated to make it harmless.

At the disposal plant the sewage first flows into a big round, concrete basin. A large rake moves around and around in the basin. This helps to expose the sewage to sunlight. The energy from the sun kills some of the disease germs that are present. The sewage is pumped from this outdoor basin to a building called a separator. This building looks somewhat like a greenhouse because it is made almost entirely of glass.

The separator contains a settling basin and a filter bed. Chemicals are added to the sewage in the settling basin. The chemicals kill the harmful bacteria. Part of the sewage falls to the bottom of the settling basin. Here it is drawn off through pipes and pumped to another building where it is dried. It can be sold as fertilizer now that the bacteria are no longer harmful.

The liquid part of the sewage is directed into the filter bed, where



it flows through layers of gravel and sand. From here it is piped into a large, rectangular, outdoor basin. The liquid remains in this basin for several days. This again helps to reduce the harmful bacteria. The liquid is then tested. If after that treatment it is found to be safe, it can be piped into a bay, lake, or river that may be near the town.

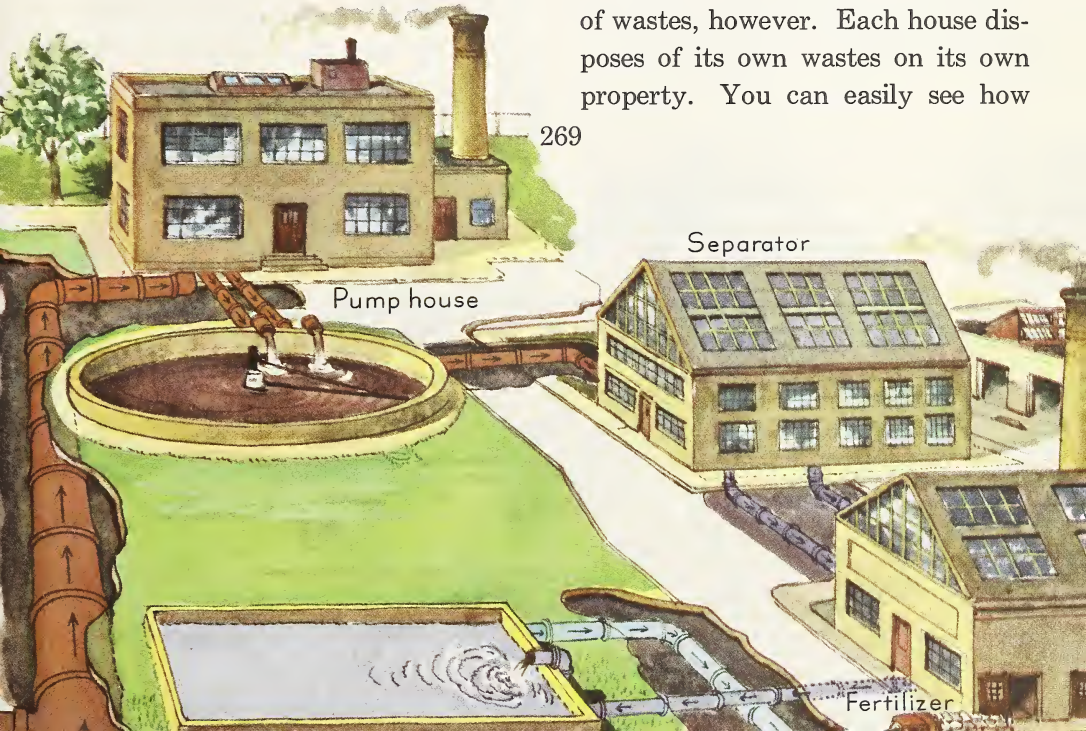
When sewage has been purified in this way, it does not pollute the water into which it flows. The beaches may be used for swimming, and animals and plant life can continue to grow in the water.

This is just one way that waste materials are disposed of without polluting water and endangering the health of people. Each city and town has its own way of disposing of sewage. How is sewage disposed of where you live?

In Small Communities

Many houses are not connected with sewers. But you would never realize it by looking at their sinks and toilets. The water and wastes are piped out of the houses just as though they were being carried to a sewer.

There is no community collection of wastes, however. Each house disposes of its own wastes on its own property. You can easily see how



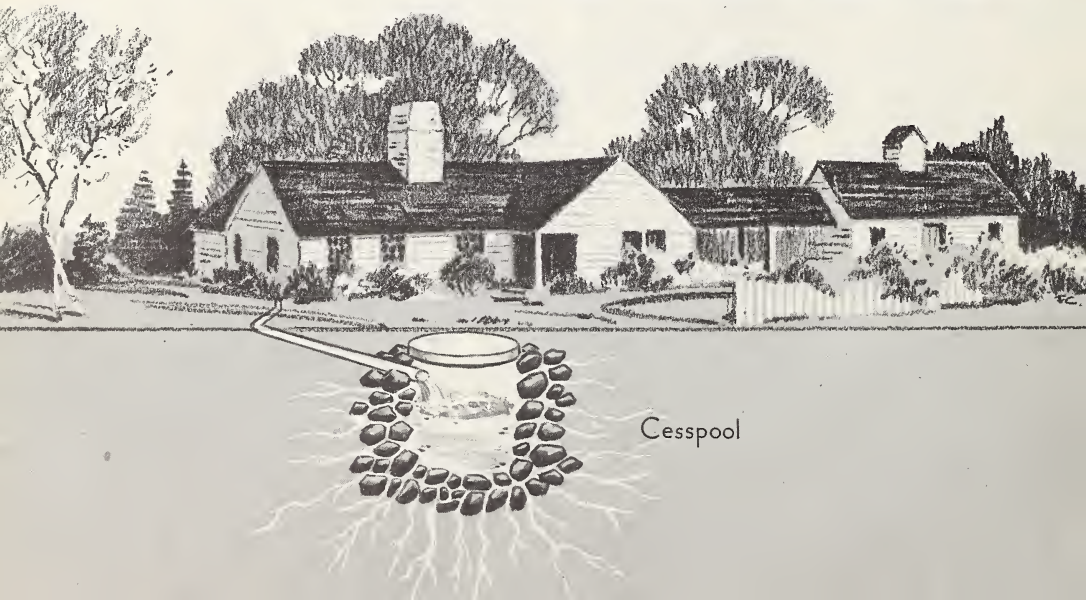
this may become a very real health problem. Each home must dispose of its wastes in such a way that they will not be harmful and cause disease.

There are two kinds of private sewage-disposal systems that are usually used: the cesspool and the septic tank. Of the two the septic tank is the safer.

A cesspool consists of a large hole in the ground. The hole is lined with rocks or concrete blocks, which are not cemented together. The top of the cesspool is covered with a tightly fitting, concrete lid. This helps to keep out insects and other animals.

The wastes from the house are carried to the cesspool through pipes. The liquids pass into the soil through the openings between the rocks or blocks. Gradually the soil around the cesspool will become polluted. Wells or nearby water supplies may be infected. Cesspools are of little use in ground that is low and wet. The soil cannot absorb the liquid from a cesspool if the soil already holds all the water that it can.

A septic tank works in an entirely different way from a cesspool. Waste materials flow into a watertight tank. The waste remains in the septic tank for 24 hours or more. During this time bacteria change much of the solid part of the waste to harmless liquid. When the height of the liquid reaches the outlet pipes, there is a flow of liquid from the tank into the soil. The area around the tank is



Cesspool

called the leaching field. Here tiles are placed just below the surface of the soil. The tiles allow air to get to the liquid. The liquid evaporates before it can go very far.

Not all the solid part of the waste is changed to liquid. Some of it remains in the tank and settles to the bottom as sludge. In time there will be an accumulation of sludge in the tank. The sludge will have to be pumped from the tank in order to keep the tank operating properly.

Disposing of Other Waste Materials

Getting rid of the wastes from our kitchens is a very serious problem also. Much of the wastes are the remains of animals and vegetables which are used for food. Then, too, there are the containers in which food was packed. These include tin cans, bottles, and paper.

The animal and vegetable remains are not a health menace when fresh. But when these remains stand for any length of time, they begin to decay. This refuse must be safely disposed of to keep the community healthy.

Sanitary Landfill Method

In some communities garbage and rubbish are taken to an open dump. These dumps attract rats, and mice, and many insects. Sometimes the waste materials in an open dump are burned. The smoke and odors are unpleasant and even harmful. In

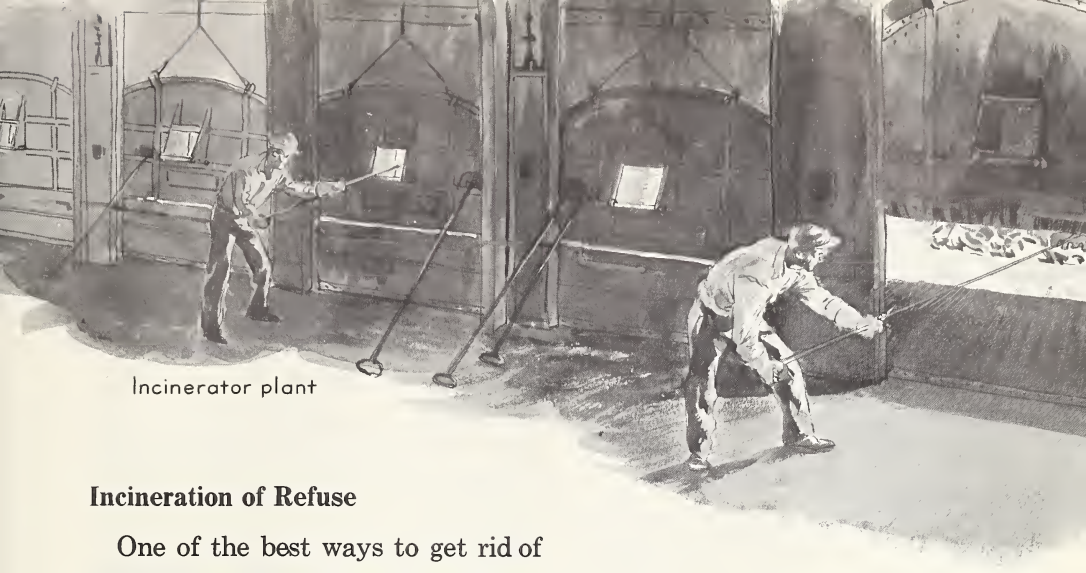
other places refuse is dumped into a river or lake, polluting the water.

Sometimes the garbage collected in cities and towns is fed to hogs. It has been found that many hogs fed untreated garbage have contracted a disease called trichinosis. This may spread to people who eat meat from these animals. In some parts of the country no garbage may be fed to hogs until after it has been heated at 212° F for 30 minutes. This destroys disease germs.

One good way to dispose of waste materials is called sanitary landfill. First, a broad, deep trench is dug by a tractor. The day's collection of refuse is dumped into part of the trench. The tractor crushes the waste materials under its steel tracks. Then soil is pressed over the refuse to make a compact covering.

When the trench is filled, other trenches are dug. Later, when all the trenches are completely filled and covered with soil, grass is planted. In some communities gravel pits, quarries, marshy places, or gullies are filled with refuse and topped with soil and grass in this way. After some time the "dump" may become a park or a playground.

In some homes garbage-disposal units have been installed in the kitchen sink. These machines grind garbage extremely fine. It is then washed down the drain and carried away with the sewage. However, in some communities widespread use of this method of garbage disposal is not yet advisable. Too much water might be wasted or the community's system of sewage disposal might be overloaded.



Incinerator plant

Incineration of Refuse

One of the best ways to get rid of community garbage and rubbish is to burn it in a specially designed furnace. The temperature in many of these garbage furnaces is about 2000° F. It is necessary to have it so hot to burn the garbage completely.

In many incinerator plants all the waste materials are not burned. Some are salvaged or separated from the rest. For example, grease and fats may be recovered from garbage by the use of steam. After the melted fat is salvaged, it is shipped to manufacturers who have use for it. Fertilizing material may also be recovered from garbage. This can be an important way of supplying fertilizers for the soils of the world.

Another important type of conservation is the salvaging of paper and rags. These may be sorted out and reused in the manufacture of paper and other products. Tin cans, other metals, and glass may also be reused in the manufacture of many things that we need. When these materials are destroyed, they are lost to us.

By using his intelligence, man has found sanitary, safe ways of disposing of garbage and other refuse. He has also found that as he removes a health menace from his community, he can recover important materials from the wastes. These salvaged materials can point the way to a richer life for all. Rather than the continued destruction of our goods and resources we can look for ways of getting fuller use of them.

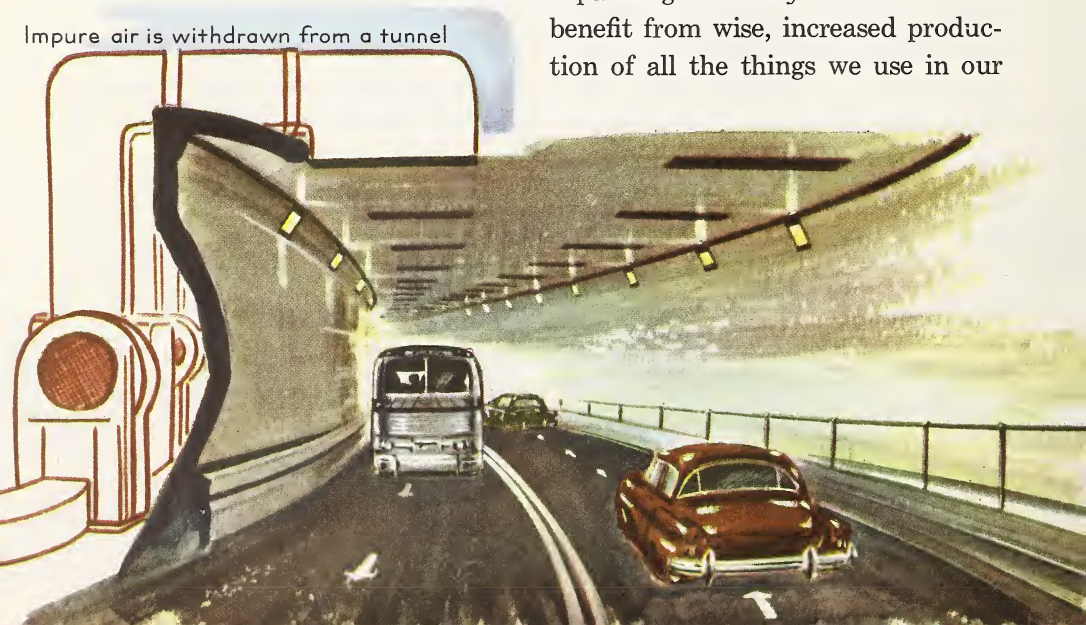
The Air You Breathe

You are probably very careful about the food and water that you take into your body each day. But what about the air you breathe? If you live in the country, it may never have occurred to you that impurities in the air may be a very serious community problem.

Many different gases, chemical compounds, and just plain dust and dirt may be in the smoke that pours out of chimneys. The mere burning of coal will throw into the air such things as soot, ash, harmful gases, and even small amounts of acids and other chemicals. The burning of natural gas or fuel oil also releases acids and other impurities. Even the drying of paints and varnishes adds fumes to the air.

If you have been in heavy automobile traffic for any length of time, you know how difficult it may become to breathe when the air is filled with fumes. Automobiles, trucks, and busses use gasoline and oil. As these fuels are used, the fumes from the exhaust pipes mix with the air we breathe.

Many other impurities are added to the air each day from some of our huge industrial plants. Impurities mix with the air as chemicals are manufactured, petroleum is refined, or as metals are worked. We are living more and more in a world of expanding industry. We will all benefit from wise, increased production of all the things we use in our



Impure air is withdrawn from a tunnel

Sampling air in an industrial area

daily living. But we should also realize that at the same time we may be polluting the air we breathe with acids and other impurities. These impurities can prove to be very harmful to the health of us all.

How do impurities in the air affect people who breathe them day in and day out during the year? This is probably one of the greatest unsolved problems we have today.

It may not take a great deal of impurity in the air to bring about ill effects. It has been estimated that we each breathe as much as 2700 gallons of air into our lungs each day. Even though there is only a small amount of impurity in each gallon that we breathe, we may take into our lungs about 2700 times that amount during the course of one day.

Impurities in the air can affect plants and animals also. Very small amounts of sulfur dioxide in the air can cause great damage to the leaves of plants such as spinach and lettuce. Other gases also can injure plants. Animals may be affected when they breathe impure air or when they feed on plants which have been damaged by gases or harmful chemicals.

Much work is being done to decrease the amount of impurities in the air. Groups from many different communities are cooperating with each other. This is important because impurities are often carried from one community to another as the air moves about.

You might find out what impurities are likely to be in the air you breathe. How do the impurities enter the air that is around you? The local Board of Health probably could give you much valuable information on this problem.

A More Healthful World

The world in which we live is becoming a more healthful place. Most people work hard at trying to keep their homes and communities clean. This is one way to prevent the spread of disease. People in health departments help in protecting communities. But it is more important that all the people in each community should become concerned about living in clean, pleasant places.

Garbage disposal, sewage disposal, and our water supply are really all part of the same problem. We cannot afford to be careless about any one of these. More and more we are realizing that each is an important link in keeping the whole community healthy.

Much has been learned about the air around us and how it affects our community health. But only a beginning has been made. There is much to find out and to do.

Probably one of the most important things man has learned is that he can change his community. He can change it for better or worse. This we know—the changes should always be the kind that benefits man. Proper planning and care can create a pleasant, clean, and healthful world in which to live. You will have a part in building this world!

LEARNING MORE

1. Find out how your community gets its water supply. Make a series of pictures showing the steps in making your water safe for drinking.

2. What diseases are spread by water? How are they caused? Report your findings to the class.

3. Make a map of your community showing where there are breeding places of insects and other animals. Put dots on the map showing where there are stagnant pools of water, marshy places, rubbish piles, open garbage cans, manure piles. After you have spotted them, find out from the Board of Health how you might help in getting rid of these breeding places.

4. In 1948 the World Health Organization was formed. It is a special agency of the United Nations. Look in an encyclopedia to find out what this organization does to make the world a more healthful place.

Science Words

This part of your book is a science dictionary. It will help you find the meanings of words which are used in your book. The page number following each word shows you on what page the word is first found.

The following list of letter sounds will help you to use correctly the markings of your science words.

ă *as in* căt	ē *as in* hēr	ô *as in* hôrse	oi *as in* soil
ā *as in* māde	ê *as in* bêgin	ȯ *as in* ȯbey	o͝o *as in* to͝ok
à *as in* gràss		o͝o *as in* so͝ft	o͞o *as in* mo͞on
å *as in* cåre	ĭ *as in* gĭft		ou *as in* out
ä *as in* bärn	ī *as in* rīde	ŭ *as in* cŭp	d͡ŭ *as in* ed͡ŭcate
		ū *as in* mūsic	ng *as in* sing
ĕ *as in* nĕt	ŏ *as in* tŏp	û *as in* bûrn	th *as in* thin
ē *as in* hē	ō *as in* jōke	ů *as in* ůnite	t͟h *as in* t͟hat

am mo'ni'um chlo'ride (ă mō'nĭ ŭm klō'rīd). A chemical compound made up of nitrogen, hydrogen, and chlorine. It is used in dry cells (p. 10).

An drom'e da (ăn drŏm'ê dà). A constellation seen in the fall and early winter. The hazy spot of light near one of its stars is the Andromeda galaxy, a system of billions of stars, a million light-years away (p. 112).

an'nu al (ăn'ů ăl). Any plant which lives only one year or season (p. 74).

Ant arc'tic Cir'cle (ănt ärk'tĭk sûr'k'l). An imaginary line circling the southern part of the earth. It marks the boundary of the south polar region (p. 42).

an'thra cite (ăn'thrà sīt). Hard coal. It burns slower than soft coal and with little smoke or flame (p. 19).

Arc'tic Cir'cle (ärk'tĭk sûr'k'l). An imaginary line circling the northern part of the earth. It marks the boundary of the north polar region (p. 41).

ar'ter y (är'tĕr ĭ). The name given to the tubes which carry the blood from the heart to all parts of the body (p. 6).

at'mos phere (ăt'mŏs fēr). The layer of gases which surrounds the land and water parts of the earth. It can be thought of as an ocean of air thousands of miles deep (p. 24).

at'om (ăt'ŭm). The smallest part into which a basic substance such as iron can be divided and still be iron. An atom consists of particles called electrons, protons, and neutrons. All substances are made up of atoms (p. 9).

a tom'ic en'er gy (ă tŏm'ĭk ĕn'ĕr jĭ). The energy which is released when atoms are broken up (p. 9).

au ro'ra bo're a'lis (ô rō'rà bō'rê ā'lĭs). Streams of light originating in the upper atmosphere of the Northern Hemisphere. They are also called northern lights (p. 209).

au'tumn (ô'tŭm). The season which follows summer. It is also called fall. In the Southern Hemisphere autumn begins about March 21 and ends about June 22 (p. 29).

ax'is (ăk'sĭs). The imaginary straight line through the center of the earth from one geographic pole to the other. The earth rotates about its axis (p. 42).

ax'le (ăk's'l). The bar or rod on which a wheel turns. Sometimes the rod rotates along with the wheel (p. 223).

bar mag'net (bär măg'nĕt). A bar of iron or steel which has the power to attract iron, steel, cobalt, and nickel (p. 190).

bas'ic ma chines' (bās'ĭk mà shēnz'). The inclined plane, lever, wheel and axle, wedge, screw, and pulley are the six basic machines. All other machines are combinations of two or more of these six (p. 222).

bi en'ni al (bī ĕn'ĭ ăl). A plant which lives for two years. It produces roots and leaves the first year and flowers, fruit, and seed the second year (p. 74).

Big Dip'per (bĭg dĭp'ẽr). A group of seven stars which one can imagine form the outline of a dipper (p. 105).

bi tu'mi nous coal (bĭ tū'mĭ nŭs kōl). A type of soft coal (p. 18).

black'smith' (blăk'smĭth'). A person who hammers iron into various shapes after heating it in a fire (p. 16).

blue'stem' grass (blo͞o'stĕm' gras). A type of grass which is highly valued for pastures. It has bluish-grey stems (p. 151).

broad'-leaved' for'ests (brôd'lēvd' fŏr'ĕsts). A growth of trees such as oaks, maples, or other trees with wide leaves (p. 151).

cal'ci um (kăl'sĭ ŭm). One of the basic substances. Calcium is one of the elements which make up the chemical called lime (p. 57).

car'bon (kär'bŏn). An element. Coal consists mostly of carbon (p. 10).

car'bon di ox'ide (kär'bŏn dī ŏk'sīd). A colorless gas made of the elements carbon and oxygen. Animals exhale carbon dioxide (p. 7).

car'i bou (kăr'ĭ bo͞o). A North American reindeer (p. 146).

cess'pool' (sĕs'po͞ol'). A deep, covered pit specially prepared to receive sewage (p. 264).

check dam (chĕk dăm). A small dam made of boards or wire. It helps to hold back the movement of water and soil down a gully (p. 169).

chem'i cal (kĕm'ĭ kăl). All things are made of chemicals. Such things as water and salt are called chemical compounds (p. 6).

chem'i cal en'er gy (kĕm'ĭ kăl ĕn'ẽr jĭ). The energy released when chemicals act on each other. Chemical energy sometimes produces heat, light, or electricity (p. 6).

chlo'rine (klō'rēn). An element which is yellowish-green in its gaseous form. Chlorine is used to help purify water (p. 266).

chlo'ro phyll (klō'rō fĭl). A chemical compound. It is the chemical which gives the green color to plants (p. 57).

cir'cuit (sûr'kĭt). A path for electricity (p. 11).

clock'wise' ro ta'tion (klŏk'wīz' rō tā'shŭn). Rotation in the same direction as that in which the hands of a clock move (p. 202).

cold'-blood'ed an'i mals (kōld'blŭd'ĕd ăn'ĭ-mălz). Animals whose blood stays about the same temperature as their surroundings. Fish and snakes are cold blooded (p. 80).

com mu'ni ty (kŏ mū'nĭ tĭ). All the plants and animals living in one place (p. 145).

com'pass (kŭm'pəs). A magnetic instrument used to tell directions (p. 189).

com plex' ma chine' (kŏm plĕks' mə shēn'). A combination of several basic machines (p. 232).

con'den sa'tion (kŏn'dĕn sā'shŭn). When water vapor in the air changes into rain, the change is called condensation (p. 24).

con'stel la'tion (kŏn'stĕ lā'shŭn). Any stars in the sky which seem to form a group. Ancient peoples imagined that these groups of stars formed the outlines of various objects, animals, and heroes (p. 105).

con'tour-plow (kŏn'to͝or plou). To plow the soil so as to take advantage of the curve of the ground (p. 178).

coun'ter clock'wise' ro ta'tion (koun'tẽr klŏk'-wīz' rō tā'shŭn). Rotation in the opposite direction from that in which the hands of a clock move (p. 202).

cur'rent of e lec'tric'i ty (kûr'ĕnt ŏv ē lĕk'-trĭs'ĭ tĭ). Electricity moving steadily from one place to another. It usually flows through a conductor such as iron or copper wire (p. 10).

de cid'u ous trees (dē sĭd'ū ŭs trēz). Trees which drop their leaves in the fall (p. 58).

di am'e ter (dī ăm'ē tẽr). The distance straight through the center of a round object, such as a circle or a planet (p. 191).

dir'i gi ble (dĭr'ĭ jĭ b'l). A huge balloon driven by motors. Helium and other gases make this aircraft lighter than air (p. 235).

drag (drăg). The force which holds back the forward movement of an airplane (p. 243).

e lec'tric'i ty (ē lĕk'trĭs'ĭ tĭ). A form of energy which results from the movement of electrons (p. 9).

e lec'trons (ē lĕk'trŏnz). The outer parts of atoms. These tiny particles have negative charges of electricity (p. 11).

el'e ment (ĕl'ē mĕnt). A basic substance made up of only one kind of atom. For example, the element oxygen is made up of nothing but oxygen atoms. There are about 100 basic substances (p. 56).

en'er gy (ĕn'ĕr jĭ). The power or ability to do something. Heat, light, and electricity are some forms of energy (p. 4).

e qua'tor (ē kwā'tĕr). An imaginary line around the center of the earth, equally distant from the north and south poles (p. 29).

e rode' (ē rōd'). To wear away. Soil is often eroded by water and wind (p. 178).

e vap'o rate (ē văp'ō rāt). To change from a liquid to a gas. When liquid water changes into gaseous water, or water vapor, we say that the water evaporates (p. 24).

ev'er green' (ĕv'ĕr grēn'). Any plant which remains green throughout the year (p. 60).

fil'ter bed (fĭl'tĕr bĕd). A layer of sand or gravel which strains out solid particles from water or other liquids (p. 265).

fric'tion (frĭk'shŭn). Resistance which comes from two surfaces rubbing on each other (p. 218).

frost line (frôst līn). The depth below ground at which water will not freeze (p. 93).

fu'el (fū'ĕl). Any material that can be used to supply heat or other forms of energy (p. 8).

ful'crum (fŭl'krŭm). The support on which a lever turns (p. 220).

fun'gus (fŭng'gŭs). A non-green plant. Bacteria, molds, and mushrooms are all fungi (p. 63).

gal'ax y (găl'ăk sĭ). A system of millions of stars. The Milky Way is the name of the galaxy to which our sun belongs (p. 99).

gas'o line (găs'ō lēn). A light, inflammable fuel obtained from petroleum oil. It is used in automobile and airplane engines (p. 21).

ge'o graph'i cal poles (jē'ō grăf'ĭ kăl pōlz). The northern and southern ends of the earth's axis (p. 196).

grass'land' (grăs'lănd'). A region of rather level land covered by grass (p. 145).

grav'i ty (grăv'ĭ tĭ). The force which pulls everything toward the center of the earth (p. 5).

ground wa'ter (ground wô'tĕr). The water stored in the soil and in layers of rock below the surface of the ground (p. 259).

heat (hēt). A form of energy which results when fuels burn, or combine rapidly with oxygen (p. 7).

hel'i cop'ter (hĕl'ĭ kŏp'tĕr). A flying machine which is driven forward by propellers revolving horizontally (p. 235).

hel'i port (hĕl'ĭ pōrt). A prepared space on which a helicopter can land (p. 248).

he'li um (hē'lĭ ŭm). A noninflammable gaseous element found on the earth and sun (p. 11).

hi'ber na'tion (hī'bĕr nā'shŭn). A state of inactivity in a protected place during cold weather (p. 92).

horned lark (hôrnd lärk). A bird often found in grassland communities (p. 162).

hy'dro gen (hī'drō jĕn). A colorless, inflammable gaseous element. When it burns in air, it combines with oxygen to form the chemical compound water (p. 9).

hy'dro pon'ics (hī'drō pŏn'ĭks). A way of growing plants without soil. Water and the necessary chemicals are supplied to plants by artificial means (p. 58).

in clined' plane (ĭn klīnd' plān). A slanting surface. A road up a hill is an inclined plane since it is a slanted surface with one end higher than the other (p. 215).

in'su lat'ed (ĭn'sŭ lāt'ĕd). Covered with a material such as rubber or cotton. The covering on insulated wire helps prevent heat or electricity from escaping (p. 127).

i'ron (ī'ẽrn). A metallic element which can be magnetized. Plants, animals, and men need iron in their food to grow (p. 5).

jet plane (jĕt plān). An airplane which is thrust through the air by a stream of hot gases escaping from its engine (p. 134).

ker'o sene' (kĕr'ō sēn'). A thin, colorless oil made from petroleum. It can be used as a fuel for many different purposes (p. 21).

leaf scar (lēf skär). The layer of tissue which grows over the spot where a leaf has been attached to a branch (p. 59).
le'ver (lē'vẽr). A bar which is used to move a heavy object. The lever is one of the six basic machines (p. 219).
li'chen (lī'kĕn). A plant usually found growing on rocks or tree trunks. It is flowerless and leafless (p. 73).
lift (lĭft). Air moving over the wings of an airplane provides its lift (p. 239).
light (līt). A form of energy. Electricity produces light energy (p. 6).
light'-year' (līt'yēr'). The distance light travels in one year (p. 103).
lime'stone' (līm'stōn'). A rock made mostly from the shells of sea animals which lived thousands of years ago. It can be cut into blocks and used for buildings (p. 19).
load'stone' (lōd'stōn'). An iron compound found in the ground. It is a natural magnet and can attract iron or steel (p. 190).

ma chine' (mà shēn'). A device which can be used to direct energy to do work. A knife, a ladder, and a shovel are examples of machines which make man's work easier (p. 9).
mag ne'si um (măg nē'shĭ ŭm). A silver-white, metallic element. Magnesium is a very light metal (p. 57).
mag net'ic field (măg nĕt'ĭk fēld). The area around a magnet in which the magnet has the power of affecting or attracting iron objects (p. 206).
mag net'ic poles (măg nĕt'ĭk pōlz). The ends of a magnet. The earth has magnetic poles (p. 194).
mag'net ism (măg'nĕ tĭz'm). The power of a substance to attract iron or steel (p. 189).
man'ga nese di ox'ide (măng'gà nēs dī ŏk'sīd). A black chemical compound made of the elements manganese and oxygen. It is used in dry cells (p. 10).
me chan'i cal en'er gy (mẽ kăn'ĭ kăl ĕn'ẽr jĭ). The energy of moving objects (p. 9).
met'al (mĕt''l). Any of several elements, such as iron or copper, which conduct electricity and glow when heated to high temperatures (p. 127).
mi'cro scope (mī'krō skōp). A scientific instrument which enlarges the size of objects seen through it (p. 126).
mi'grate (mī'grāt). To travel at regular intervals from one place to another (p. 86).
Milk'y Way (mĭl'kĭ wā). A broad band of pale-white light which stretches across the sky at night (p. 98).
Milk'y Way sys'tem (mĭl'kĭ wā sĭs'tĕm). All the stars which belong to our Galaxy. Our sun is one of these stars (p. 108).
min'er al (mĭn'ẽr ăl). A substance occurring in nature. It may be either an element or a compound. Coal, gold, salt, and copper ore are a few minerals (p. 26).
mol'e cule (mŏl'ẽ kūl). All molecules are composed of atoms. A molecule of water is made of two atoms of hydrogen and one atom of oxygen. A drop of water consists of millions of molecules of water (p. 197).

ni'tro gen (nī'trō jĕn). An element in the air in the form of a gas which is colorless, odorless, and tasteless. Nitrogen is also found in the soil as a part of nitrates. A nitrate is a chemical that contains nitrogen and oxygen (p. 57).
non'-green' plants (nŏn'grēn' plănts). Plants which do not contain chlorophyll and are unable to make their own food (p. 63).
North Star (nôrth stär). The star toward which the northern end of the earth's axis seems to point. It is often called the pole-star (p. 43).
North'ern Hem'i sphere (nôr'thẽrn hĕm'ĭ-sfēr). That half of the earth which is north of the equator (p. 29).

oil shale (oil shāl). Shale rock which has become soaked with petroleum (p. 21).

O ri'on (ō rī'ŏn). A large constellation with three bright stars in a line. Early peoples imagined that these formed the belt of the hunter Orion (p. 105).

ox'y gen (ŏk'sĭ jĕn). An element found as a gas in the air we breathe. It is colorless, odorless, and tasteless, and is necessary for life. It is a part of many chemical compounds, such as water and sugar (p. 132).

peat (pēt). A dark material formed of partly decayed trees and other plant life in swamps. It may be used as a fuel (p. 18).

per en'ni al (pĕr ĕn'ĭ ăl). Any kind of plant that lives on from year to year (p. 74).

pe tro'le um (pē trō'lē ŭm). A dark, oily liquid obtained by drilling wells. Gasoline, kerosene, motor oil, and certain waxes are obtained from petroleum (p. 19).

phos'pho rus (fŏs'fō rŭs). An element that is yellowish and waxy when pure. It is an important part of many chemical compounds found in soil and foods (p. 57).

plan'et (plăn'ĕt). One of nine bodies in the solar system which revolve around the sun. We live on the planet called Earth (p. 40).

po'rous (pō'rŭs). Full of tiny holes. Liquids can pass through porous material. Sandstone is a porous rock (p. 260).

po tas'si um (pō tăs'ĭ ŭm). A soft, bluish-white, metallic element. Potassium compounds are found in soil and are very important to plants and animals (p. 57).

prai'rie re'gions (prâr'ĭ rē'jŭnz). Large, treeless tracts of level or gently rolling grassland. The central portion of the United States is a prairie region (p. 151).

pre cip'i ta'tion (prē sĭp'ĭ tā'shŭn). Water that falls as rain, snow, sleet, or hail (p. 152).

pro pel'ler (prō pĕl'ĕr). A device for pulling a plane forward through the air. It may have two, three, or four blades (p. 240).

Prox'i ma Cen tau'ri (prŏk'sĭ mà sĕn tô'rī). The star nearest our solar system (p. 103).

pul'ley (po͝ol'ĭ). A basic machine consisting of a wheel with a grooved rim into which a rope fits (p. 226).

re flect' (rē flĕkt'). To turn back light. We see most objects by the light which they reflect (p. 142).

re volve' (rē vŏlv'). To move around in a circular or curved path. It takes the earth 365¼ days, or one year, to revolve once around the sun (p. 40).

rock'et en'gine (rŏk'ĕt ĕn'jĭn). A type of engine which carries its own oxygen supply. It does not rely upon the oxygen in the atmosphere to burn its fuel (p. 253).

root hairs (ro͞ot hârz). Little extensions on roots through which water enters. Root hairs are small, thin tubes closed at the free end (p. 55).

ro'tate (rō'tāt). To turn on an axis the way a wheel turns on its axis. The earth rotates once every 24 hours (p. 40).

rust (rŭst). Iron oxide. This reddish-brown chemical compound forms when iron combines with the oxygen in the air (p. 5).

sand'stone' (sănd'stōn'). A rock made up of small particles of sand (p. 18).

screw (skro͞o). One of the six basic machines. A screw is a slender, round bar having a spiral strip of metal, or thread (p. 226).

sea lev'el (sē lĕv'ĕl). The height of land is usually measured from sea level. Sea level is set at halfway between the height of high and low tide (p. 17).

sep'a ra'tion lay'er (sĕp'à rā'shŭn lā'ĕr). A thin layer which grows between the stalk of a leaf and the branch on which the leaf is growing (p. 59).

sep'tic tank (sĕp'tĭk tăngk). An underground tank in which sewage is held until it becomes harmless (p. 270).

set'tling ba'sin (sĕt'lĭng bā's'n). A reservoir where water or other liquid is kept for a while to allow soil or solid particles to settle to the bottom (p. 265).

shale (shāl). Rock consisting mostly of clay which has been pressed and hardened (p. 18).

Sir'i us (sĭr'ĭ ŭs). A brilliant star often called the dog star (p. 104).

sound (sound). A form of energy which comes from vibrations (p. 7).

South'ern Hem'i sphere (sŭ̶th'ẽrn hĕm'ĭ-sfēr). That half of the earth south of the equator (p. 30).

spring (sprĭng). The season of the year following winter. In the Southern Hemisphere spring begins about September 23 and ends about December 22 (p. 30).

spring bal'ance (sprĭng băl'ăns). A device for measuring weight or force by means of a spiral spring (p. 217).

star (stär). A body, such as our sun, which gives off light and heat (p. 31).

steam en'gine (stēm ĕn'jĭn). An engine run by steam. Steam engines were used in early steamboats and locomotives (p. 16).

sul'fur (sŭl'fẽr). A yellow, nonmetallic element used in gunpowder and matches. It is also an important part of many foods (p. 57).

sul'fur di ox'ide (sŭl'fẽr dī ŏk'sīd). A chemical compound which forms when sulfur combines with oxygen. When mixed with water, it forms a harmful acid (p. 275).

sum'mer (sŭm'ẽr). The season of the year following spring. In the Southern Hemisphere summer begins about December 22 and ends about March 21 (p. 30).

sun (sŭn). The star about which the earth and other planets revolve. It supplies us with light and heat (p. 9).

sun'spots' (sŭn'spŏts'). Dark spots sometimes seen on the sun's surface. They are believed to be giant cyclones (p. 209)

sur'face wa'ter (sûr'fĭs wô'tẽr). The water which moves along or collects on the surface of the land (p. 259).

the'o ry (thē'ō rĭ). An opinion usually based on some observed facts. It may help to explain why something occurs (p. 11).

ther'mo stat (thûr'mō stăt). An automatic device for controlling temperature (p. 81).

thrust (thrŭst). The force which moves an airplane forward through the air (p. 241).

top'soil' (tŏp'soil'). The loose, top layer of the earth's surface (p. 19).

trib'u tar'y (trĭb'ū tẽr'ĭ). A stream or river which flows into a larger river or lake (p. 174).

tril'lion (trĭl'yŭn). One million million, or 1,000,000,000,000 (p. 103).

Trop'ic of Can'cer (trŏp'ĭk ŏv kăn'sẽr). An imaginary circle around the earth north of the equator. The sun is directly overhead at the Tropic of Cancer on June 22 (p. 41).

Trop'ic of Cap'ri corn (trŏp'ĭk ŏv kăp'ṛĭ-kôrn). An imaginary circle around the earth south of the equator. The sun is directly overhead at the Tropic of Capricorn on December 22 (p. 42).

tun'dra (tŏŏn'drȧ). A vast stretch of flat or gently rolling marshy land in the north arctic region (p. 162).

tung'sten (tŭng'stĕn). A metallic element used for the wires in electric-light bulbs (p. 130).

u ra'ni um (ū rā'nĭ ŭm). A hard, heavy, white, metallic element found in pitchblende. It is used to produce atomic energy (p. 26).

veins (vānz). Tubes in our bodies through which blood moves from all parts of the body back to the heart (p. 6).

warm'-blood'ed an'i mals (wôrm'blŭd'ẽd ăn'ĭ mălz). Animals which maintain a rather constant temperature even though the temperature of the places in which they live moves up and down (p. 80).

wa'ter shed' (wô'tẽr shĕd'). The sloping land from which water drains into streams, rivers, or lakes (p. 181).

wedge (wĕj). One of the six basic machines. It is usually a piece of wood or metal thick at one end and thin at the other (p. 226).

wind'lass (wĭnd'lȧs). A machine for hoisting or hauling. It usually consists of a wheel and axle (p. 223).

win'ter (wĭn'tẽr). The season of the year following autumn. In the Southern Hemisphere winter begins about June 22 and ends about September 23 (p. 30).

zinc (zĭngk). The bluish-white metallic element of which the covering of a dry cell is made (p. 10).

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